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(54) Title: USE OF DYE TO DISTINGUISH SALT AND PROTEIN CRYSTALS UNDER MICROCRYSTALLIZATION CONDITIONS

(57) Abstract: An improved method of screening crystal growth conditions is provided wherein molecules are crystallized from solutions containing dyes. These dyes are selectively incorporated or associated with crystals of particular character thereby rendering crystals of particular character colored and improving detection of the dyed crystals. A preferred method involves use of dyes in protein solutions overlayed by oil. Use of oil allows the use of small volumes of solution and facilitates the screening of large numbers of crystallization conditions in arrays using automated devices that dispense appropriate solutions to generate crystallization trials, overlay crystallization trials with an oil, provide appropriate conditions conducive to crystallization and enhance detection of dyed (colored) or undyed (uncolored) crystals that result.

USE OF DYE TO DISTINGUISH SALT AND PROTEIN CRYSTALS UNDER MICROCRYSTALLIZATION CONDITIONS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of priority of U.S. Provisional Application No. 60/308,698, filed July 30, 2001, to Provisional Application Serial No. 60/328,958, filed October 12, 2001, and to U.S. application Serial No. 09/543,326, filed April 5, 2000, which claims benefit of U.S. Provisional Application 60/128,018, filed April 6, 1999, each of which are hereby incorporated in their entirety herein by reference.

STATEMENT OF GOVERNMENT SUPPORT

This invention was made with government support under NASA Cooperative Agreement No. NCC8-246. The government may have certain rights in the invention.

FIELD OF THE INVENTION

This invention relates generally to the method of using detectable agents in crystallization of proteins, wherein the detectable agents are preferentially incorporated in the crystals of proteins or preferentially not incorporated in the crystals of proteins such that protein crystals can be readily distinguished from crystals of other substances which can form under the crystallization conditions, thereby allowing rapid and straightforward characterization of crystals and evaluation of crystallization conditions used to obtain the crystals.

SUMMARY OF THE INVENTION

In accordance with the purpose(s) of this invention, as embodied and broadly described herein, this invention relates to a method of using dyes to facilitate the

characterization of protein crystals present in volumes of one microliter or less. Specifically, it relates to the crystallization of proteins from protein solutions containing dyes under conditions wherein the proteins which crystallize and the other components of the protein solutions which crystallize can be distinguished from one another on the basis of whether or not they form dyed crystals.

In a first aspect, this invention relates to a method for forming a dyed protein crystal including the steps of: (1) providing a protein solution, wherein the protein solution contains at least one dye, which dye is capable of dyeing at least a portion of protein crystals formed from the protein solution; (2) subjecting the protein solution to environmental conditions effective to form protein crystals; and (3) detecting the presence of dyed protein crystals, whereby the presence of the dyed protein crystals indicates the presence of protein crystals.

In various preferred embodiments of the first aspect of the invention, the dye can be chosen from the group consisting of methylene blue, methylene green, Izit[1] and crystal violet.

In various preferred embodiments of the first aspect of the invention, the protein solution is partitioned from the atmosphere. When the protein solution is partitioned from the atmosphere, the partitioning can be done so as to lower the rate at which transfer of solvent from the protein solution occurs. The protein solution can be partitioned from the atmosphere by overlaying the protein solution with an oil. The overlaying oil can be selected from the group consisting of paraffin oil, silicone oil or a combination thereof, for example, AL's oil[1] (a 1:1 mixture of paraffin and silicone oil). The particular mixture of oil selected can be optimized for the rate at which transfer of solvent from a protein solution occurs when the protein solution is overlayed with a particular mixture of oil. Further, the amount of oil overlaying the protein solution can

[1] Reagent is commercially available from Hampton Research, Inc. (www.hamptonresearch.com)

be selected so as to optimize the rate of solvent transfer from the protein solution, in particular, from the protein solution to the oil and from the oil to the atmosphere.

In various preferred embodiments of the first aspect of the invention, the protein solution further includes a component selected from the group consisting of salts, buffers, precipitants, crystallization aids and any combination thereof. The component selected can crystallize under the controlled environmental conditions to which the protein solution is subjected, thereby producing component crystals. The conditions under which the component crystallizes, can include the step or process of adding a precipitate solution. The component crystals formed can be undyed component crystals.

In various preferred embodiments of the first aspect of the invention, any crystals formed in the provided protein solution can be detected. If crystals are detected, dyed protein crystals can be distinguished from undyed component crystals. The protein crystals and component crystals can be detected by microscopy.

In a second aspect, this invention relates to a method for screening protein crystal growth conditions, including the steps of: (1) providing a set of at least two protein solutions, wherein the protein solutions contain a dye, which is capable of dyeing at least a portion of protein crystals formed from the protein solution and which does not dye a significant portion of component crystals formed from the protein solution; (2) subjecting the protein solutions to predetermined conditions, wherein the environmental conditions to which each member of the set of protein solutions is subjected is not identical to the environmental conditions to which another member of the set is subjected; and (3) detecting the presence or non-presence of dyed protein crystals and/or undyed component crystals, wherein the presence of the dyed protein crystals indicates the formation of protein crystals; and the presence of undyed component crystals indicates formation of component crystals.

In various preferred embodiments of the second aspect of the invention, the set of protein solutions consists of greater than 10, 50, 100, 250, 500, 1000, 1500, 2000 or 5000 protein solutions.

In various preferred embodiments of the second aspect of the invention, the dye can be chosen from the group consisting of methylene blue, methylene green, Izit[1] and crystal violet.

In various preferred embodiments of the second aspect of the invention, the protein solutions are partitioned from the atmosphere. When the protein solutions are partitioned from the atmosphere, the partitioning can be done so as to lower the rate at which transfer of solvent from the protein solutions occurs. The protein solutions can be partitioned from the atmosphere by overlaying the protein solutions with an oil. The overlaying oil can be selected from the group consisting of paraffin oil, silicone oil or a combination thereof, for example, AL's oil[1] (a 1:1 mixture of paraffin and silicone oil). The particular mixture of oil selected can be optimized for the rate at which transfer of solvent from a protein solution occurs when the protein solution is overlayed with a particular mixture of oil. Further, the amount of oil overlaying the protein solution can be selected so as to optimize the rate of solvent transfer from the protein solution, in particular, from the protein solution to the oil and from the oil to the atmosphere.

In various preferred embodiments of the second aspect of the invention, the protein solutions further include a component selected from the group consisting of salts, buffers, precipitants, crystallization aids and any combination thereof. The component selected can crystallize under the controlled environmental conditions to which the protein solution is subjected, thereby producing component crystals. The conditions under which the component crystallizes, can include the step or process of

adding a precipitate solution. The component crystals formed can be undyed component crystals.

In various preferred embodiments of the second aspect of the invention, any crystals formed in the provided protein solutions can be detected. If crystals are detected, dyed protein crystals can be distinguished from undyed component crystals. The protein crystals and component crystals can be detected by microscopy.

In various preferred embodiments of the second aspect of the invention, the detection of dyed protein crystals indicates a combination of environmental conditions to promote crystal growth of a protein in the provide protein solutions. When dyed proteins are detected, the dyed protein crystals can be evaluated in respect to protein crystal quality. Evaluation of protein crystal quality can include consideration of criteria selected from the group consisting of, but not limited to, size of crystals, volume of crystals, intensity of coloration of crystals by dye, color of coloration of crystals by dye, sharpness of crystal edges, and crystal shape.

In various preferred embodiments of the second aspect of the invention, the suitability of crystallization conditions can include evaluation of the protein crystal quality of the crystals obtained by a certain set of environmental conditions.

In a third aspect, this invention relates to a method of forming a dyed component crystal including the steps of: (1) providing a component solution, wherein the component solution contains at least one dye, which dye is capable of dyeing at least a portion of component crystals formed from the component solution; (2) subjecting the component solution to environmental conditions effective to form component crystals; and (3) detecting the presence of dyed component crystals, whereby the presence of the dyed component crystals indicates the presence of component crystals.

In various preferred embodiments of the third aspect of the invention, the component solution is partitioned from the atmosphere. When the component solution is partitioned from the atmosphere, the partitioning can be done so as to lower the rate at which transfer of solvent to or from the component solution occurs. The component solution can be partitioned from the atmosphere by overlaying the component solution with an oil. The overlaying oil can be selected from the group consisting of paraffin oil, silicone oil or a combination thereof, for example, AL's oil[1] (a 1:1 mixture of paraffin and silicone oil). The particular mixture of oil selected can be optimized for the rate at which transfer of solvent to or from the component solution occurs when the component solution is overlayed with a particular mixture of oil. Further, the amount of oil overlaying the component solution can be selected so as to optimize the rate of solvent transfer to or from the component solution, in particular, from the component solution to the oil, or vice versa, and from the oil to the atmosphere, or vice versa.

In various preferred embodiments of the third aspect of the invention, the component solution further includes a protein. The protein selected can crystallize under the controlled environmental conditions to which the component solution is subjected, thereby producing protein crystals. The conditions under which the protein crystallizes, can include the step or process of adding a precipitate solution. The protein crystals formed can be dyed protein crystals.

In various preferred embodiments of the third aspect of the invention, any crystals formed in the provided component solution can be detected. If crystals are detected, protein crystals can be distinguished from component crystals on the basis that the protein crystals are undyed protein crystals and the component crystals are dyed component crystals. The protein crystals and component crystals can be detected by microscopy.

In a fourth aspect, this invention relates to a method for screening protein crystal growth conditions including the steps of: (1) providing a set of at least two protein solutions, wherein the protein solutions contain a dye, which is capable of dyeing at least a portion of component crystals formed from the protein solution and which does not dye a significant portion of protein crystals formed from the protein solution; (2) subjecting the protein solutions to predetermined conditions, wherein the environmental conditions to which each member of the set of protein solutions is subjected is not identical to the environmental conditions to which another member of the set is subjected; and (3) detecting the presence or non-presence of undyed protein crystals and/or dyed component crystals. The presence of the undyed protein crystals can indicate the formation of protein crystals and the presence of the dyed component crystals can indicate formation of component crystals.

In various preferred embodiments of the fourth aspect of the invention, the set of protein solutions consists of greater than 10, 50, 100, 250, 500, 1000, 1500, 2000 or 5000 protein solutions.

In various preferred embodiments of the fourth aspect of the invention, the protein solutions are partitioned from the atmosphere. When the protein solutions are partitioned from the atmosphere, the partitioning can be done so as to lower the rate at which transfer of solvent from the protein solutions occurs. The protein solutions can be partitioned from the atmosphere by overlaying the protein solutions with an oil. The overlaying oil can be selected from the group consisting of paraffin oil, silicone oil or a combination thereof, for example, AL's oil[1] (a 1:1 mixture of paraffin and silicone oil). The particular mixture of oil selected can be optimized for the rate at which transfer of solvent from a protein solution occurs when the protein solution is overlayed with a particular mixture of oil. Further, the amount of oil overlaying the protein solution can be selected so as to optimize the rate of solvent transfer from the protein solution, in particular, from the protein solution to the oil and from the oil to the atmosphere. The

overlaying oil used, or the amount of overlaying oil used, to partition any single protein solution from the atmosphere can be the same or can be different than the overlaying oil used to partition any other protein solution from the atmosphere.

In various preferred embodiments of the fourth aspect of the invention, the protein solutions can further include a component selected from the group consisting of salts, buffers, precipitants, crystallization aids and any combination thereof. The component selected can crystallize under the controlled environmental conditions to which the protein solution is subjected, thereby producing component crystals. The conditions under which the component crystallizes, can include the step or process of adding a precipitate solution. The component crystals formed can be dyed component crystals.

In various preferred embodiments of the fourth aspect of the invention, crystals formed in the provided protein solutions can be detected. If crystals are detected, protein crystals can be distinguished from component crystals on the basis that the protein crystals are undyed protein crystals and the component crystals are dyed component crystals. The protein crystals and component crystals can be detected by microscopy.

In various preferred embodiments of the fourth aspect of the invention, the detection of undyed protein crystals indicates a combination of environmental conditions to promote crystal growth of a protein in the provided protein solutions. When undyed proteins are detected, the undyed protein crystals can be evaluated in respect to protein crystal quality. Evaluation of protein crystal quality can include consideration of criteria selected from the group consisting of, but not limited to, size of crystals, volume of crystals, intensity of coloration of crystals by dye, color of coloration of crystals by dye, sharpness of crystal edges, and crystal shape.

In various preferred embodiments of the fourth aspect of the invention, the method of screening the suitability of crystallization conditions can include an evaluation of the characteristics, numbers or types of component crystals formed.

Additional advantages of the invention will be set forth in part in the description, which follows, and in part will be obvious from the description, or can be learned by practice of the invention. The advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the appended claims. It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention, as claimed.

For instance, one advantage provided by one aspect of the invention is that the use of the dye to distinguish between salt and protein crystals allows rapid screening of crystals formed in volumes of less than or equal to approximately one microliter to distinguish between those formed of salt and those formed of protein. The methods known to the art at this time that are used to distinguish between crystals of salt and crystals of protein are not able to achieve this result. The methods used now: (1) the "crush test" where an investigator feels and listens for the sound of salt cracking; (2) bombardment of a crystal by x-rays and subsequent diffraction pattern analysis; and (3) addition of dye after a crystal has been grown and observation of staining; each require a crystal of suitable size (0.3 mm x 0.3 mm x 0.3 mm). Crystals grown from volumes of solution less than or equal to approximately one microliter are too small for these classical methods of analysis. The salt and protein crystals formed are too small to crush or to manipulate effectively for x-ray bombardment. Also, because the volumes in which the crystals are formed are so small, addition of any feasibly manipulated volume of dye solution has significant effects on the composition of the solution containing the crystals and, therefore, significant effects on the crystals therein. Furthermore, as use of such small volumes requires that the crystals be grown in

solutions partitioned from the atmosphere, generally by an overlaying oil, it is extremely difficult to add a dye reagent to protein solutions containing crystals. Inclusion of protein solutions prior to crystal growth provides an extremely efficient and simple method to screen for protein crystals in volumes of less than one microliter. Further, this method reduces the time, cost, and skill labor requirements for screening procedures as well as lending itself to forms of automated screening, including for example, methods of automated screening described in U.S. application Serial No. 09/543,326 incorporated herein by reference.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 depicts micrograph images of crystallization trials. (Fig. 1A) Izit under oil. (Fig. 1B) NaCl under oil. (Fig. 1C) NaCl + dye under oil. (Fig. 1D) Lysozyme under oil. (Fig. 1E) Lysozyme + dye under oil. (Fig. 1F) Thaumatin under oil. (Fig. 1G) Thaumatin + dye under oil. (Fig. 1H) Catalase under oil. (Fig. 1I) Catalase + dye under oil. (Fig. 1J) Trypsin under oil. (Fig. 1K) Trypsin + dye under oil using CS15. (Fig. 1L) Trypsin + dye under oil using CS16. In each trial, the oil was AL's oil, 50:50 mixture of paraffin oil and silicone oil and the dye was Izit.

Figure 2 depicts a lysozyme crystal. This dyed protein crystal, at the lower left quadrant of the well, was grown in the presence of Izit and has incorporated blue dye.

Figure 3 depicts a pepsin crystal. This dyed protein crystal was grown in the presence of Izit and has incorporated blue dye.

Figure 4 depicts a β-lactoglobulin crystal. This dyed protein crystal was grown in the presence of Izit and has incorporated blue dye.

Figure 5 depicts micrograph images of additional crystallization trials. Figs. 5A-5D depict trials conducted using Izit w/o any added protein under various screening

conditions. 5E-5F depict trials with added β-lactoglobulin. Figures 5G-5I depict trials with added myristol transferase. Figure 5J depicts trials with added pepsin. Figures 5K and 5L depict trials with protein Renac2. Figures 5M and 5N depict trials with protein ROB1. Figure 5O depicts a trial with protein B10.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention may be understood more readily by reference to the following detailed description of preferred embodiments of the invention and the Examples included therein and to the Figures and their previous and following description.

Before the present compounds, compositions, articles, devices, and/or methods are disclosed and described, it is to be understood that this invention is not limited to specific methods of using dye to distinguish between crystals of interest and crystals of other character, specific dyes, to specific methods of detecting dyed crystals or to particular uses of the method disclosed herein, as such may, of course, vary. It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting.

As used in the specification and the appended claims, the singular forms "a," "an" and "the" include plural referents unless the context clearly dictates otherwise. Thus, for example, reference to "a dye" includes mixtures of dyes, reference to "a component" includes mixtures of two or more such components, and the like.

Ranges may be expressed herein as from "about" one particular value, and/or to "about" another particular value. When such a range is expressed, another embodiment

includes from the one particular value and/or to the other particular value. Similarly, when values are expressed as approximations, by use of the antecedent "about," it will be understood that the particular value forms another embodiment. It will be further understood that the endpoints of each of the ranges are significant both in relation to the other endpoint, and independently of the other endpoint.

In this specification and in the claims, which follow, reference will be made to a number of terms, which shall be defined to have the following meanings:

"Optional" or "optionally" means that the subsequently described event or circumstance may or may not occur, and that the description includes instances where said event or circumstance occurs and instances where it does not. For example, the phrase "solution optionally containing precipitate" means that the solution may or may not contain precipitate and that the description includes both a solution without precipitate and a solution with a precipitate.

"Detectable," as used herein, means that the presence or absence of the molecule or species so described can be determined. Alternatively, "detectable," as used herein, means that the presence or absence of a certain property or characteristic of a molecule or species so described can be determined. For example, a visually detectable characteristic or property of a species or object, such as a crystal, includes, but is not limited to, the intensity, shade and hue of the species or object.

"Dye," as used herein, means an agent which renders another molecule or species detectable by its action on or association with the other molecule or species. Generally, a dye will refer to a visually detectable small molecule, which interacts with, i.e. stains or colors, another molecule. However, dye, as used herein, may also mean an agent that acts on another molecule to render it detectable. Dye, as used herein, may

also mean an agent, which absorbs or emits electromagnetic radiation outside of the visible spectrum, e.g., electromagnetic radiation within the ultraviolet spectrum.

"Environment" or "environmental conditions," as used herein, means the sum total of all the conditions and elements that make up the surroundings and influence the development of any species subject to the environment. The environmental conditions of a protein in solution can be defined in part by description of a limited number of conditions and elements, including but not limited to the identity and abundance of atoms or molecules in solution, including but not limited to solvents, solutes and precipitates; other conditions such as but not limited to pH, temperature and pressure; and the magnitude and orientation of other forces, including but not limited to gravitational forces, magnetic forces and electrostatic forces.

It will be recognized by one of skill in the art that individual substitutions, deletions or additions which alter, add or delete a single amino acid or a small percentage of amino acids (typically less than 5%, more typically less than 1%) in an encoded sequence are conservatively modified variations where the alterations result in the substitution of an amino acid with a chemically similar amino acid. Conservative substitution tables providing functionally similar amino acids are well known in the art. The following six groups each contain amino acids that are conservative substitutions for one another:

1) Alanine (A), Serine (S), Threonine (T);
2) Aspartic acid (D), Glutamic acid (E);
3) Asparagine (N), Glutamine (Q);
4) Arginine (R), Lysine (K);
5) Isoleucine (1), Leucine (L), Methionine (M), Valine (V); and 6) Phenylalanine (F), Tyrosine (Y), Tryptophan (W).

Further, it will be recognized by one of skill in the art that two polynucleotides or polypeptides are said to be "identical" if the sequence of nucleotides or amino acid residues in the two sequences is the same when aligned for maximum correspondence. Optimal alignment of sequences for comparison may be conducted by the local homology algorithm of Smith and Waterman *Adv. Appl. Math.* 2: 482 (1981), by the homology alignment algorithm of Needleman and Wunsch, *J. Mol. Biol.* 48: 443 (1970), by the search for similarity method of Pearson and Lipman, *Proc. Natl. Acad. Sci. U.S.A.* 85: 2444 (1988), by computerized implementations of these algorithms (GAP, BESTFIT, FASTA, and TFASTA in the Wisconsin Genetics Software Package, Genetics Computer Group, 575 Science Dr., Madison, WI), or by inspection.

The dye(s) used in the practice of the invention may have no effect on the crystallization of a protein contained in the solution. While not being bound by theory, it is contemplated that the nature of the interaction between the selected dyes and protein crystals is such that it has no effect on the structure, stability or growth characteristics of the protein crystals of interest.

The dye(s) used in the practice of the invention may have a negligible effect on the crystallization of proteins contained in the solution. For example, protein crystals formed in the presence of the dye may be functionally equivalent in respect to their use to determine the structure of the crystallized protein, even though the protein crystals grown in the presence of the dye can be distinguished from the protein crystals grown in the absence of the dye on the basis of criteria that can be used to evaluate protein crystal quality, including the size of crystals, volume of crystals, sharpness of crystal edges and crystal shape.

The dye(s) used in the practice of the invention may have a significant effect on the crystallization of proteins contained in the solution. For example, the protein crystals' growth may be significantly slower when the protein solution contains the dye

or the protein crystals' growth may be significantly faster when the protein solution contains the dye. Significant differences in the growth rate of protein crystals are those greater than 5, 10, 15, 25, 50, 75, 100, 500 or 1000 fold different. Also, the quality of the crystals may be significantly different, as measured by the criteria for determining a protein crystal's quality, for example, size of crystals, volume of crystals, intensity of coloration of crystals by dye, color of coloration of crystals by dye, sharpness of crystal edges, and crystal shape.

It will be recognized that under some conditions, for example, when using Izit dye under high salt conditions and at low pH, colored dye crystals can be formed in the absence of protein. It will also be recognized that under some conditions, certain buffer components or salts can crystal with the dyes used to form colored crystals. Formation of such colored dye-only or colored component crystals can be detected by screening for the formation of colored crystals in the absence of any added protein or biomolecule of interest. Detection of the presence or absence of such colored crystals under such conditions can be used by one of skill in the art to evaluate the authenticity of colored crystals formed under such conditions when protein or the biomolecule of interest is present.

Screening protein crystal growth conditions, as is described herein, refers broadly to the process of providing at least two protein solutions and subjecting them to different conditions and then determining whether or not the conditions allow for the crystallization of proteins included in the protein solution. The protein solutions, unless otherwise indicated, contain the same protein species, which is the protein of interest. When the protein solutions contain the same protein of interest, the environmental conditions that a given protein solution is subjected to can differ. The protein solutions can also contain different protein species. When the protein species contained in the different protein solutions differ, the protein species that differ may be either the protein of interest and/or other proteins. The protein of interest, as will be recognized

by those of skill in the art, is the protein for which the evaluation of protein crystallization conditions is intended. In other words, if an investigator is seeking to establish suitable conditions for the crystallization of protein X, then protein X is the protein of interest.

The volume of a protein solution used in the method of forming dyed or undyed protein crystals or in screening protein crystallization conditions, as is described herein, can be greater than 1, 5, 10, 25, 50, 75, 100, 150, 200, 250, 300, 400, 500, 600, 700, 800 or 900 pico-, nano-, or micro-liters. The volume of a protein solution used in the method of forming dyed or undyed protein crystals or in screening protein crystallization conditions, as is described herein, can be less than 5, 10, 25, 50, 75, 100, 150, 200, 250, 300, 400, 500, 600, 700, 800, 900, or 1000 milli-, micro-, nano- or pico-liters.

"Partitioned," as used herein, refers to the segregation of the protein solution from the atmosphere such that the transfer of at least one species present in the solution from the solution to the atmosphere occurs at a lower rate than when the protein solution is not partitioned from the atmosphere. For example, segregation of the protein solution from the atmosphere by the interposition of a semipermeable membrane, which allows the passage of certain solvent molecules, but not others, would partition the protein solution from the atmosphere. When the protein solution is partitioned from the atmosphere, the partitioning may be done so as to lower the rate at which transfer of solvent from the protein solution occurs. The protein solution may be partitioned from the atmosphere by overlaying the protein solution with an oil. The overlaying oil may be selected from the group consisting of paraffin oil, silicone oil or a combination thereof, for example, AL's oil[1] (a 1:1 mixture of paraffin and silicone oil). The particular overlaying oil selected may be optimized for the rate at which transfer of solvent from a protein solution occurs when the protein solution is overlayed with a particular mixture of oil. Paraffin oil is more restrictive to evaporation of water

from the overlayed protein solution than either silicone oil or mixtures containing paraffin oil and silicone oil. Mixtures of the two oils can be used where the rate of evaporation to be allowed falls between the rate allowed when 100% paraffin oil is used and when 100% silicone oil is used. Mixtures of the two oils having higher paraffin oil/silicone oil ratios are more restrictive to transfer of water molecules than those mixtures of oil having lower paraffin oil/silicone oil ratios. In mixtures of the two oils, the %(v/v) of either of the two oils, either the paraffin oil or the silicone oil, can be 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90 or 95%.

The practice of protein crystallization to provide crystals suitable for x-ray diffraction and/or other methods of analysis is often hampered by the difficulty in obtaining crystals of sufficient size and quality for analysis. Thus, the most powerful technique currently available for studying the structure of large molecules can often not be applied to molecules for which there is a need for greater understanding to solve pressing questions relating to the health and welfare of humankind. While the barrier of insufficient crystal quality can often be breached with the application of sufficient resources, the elucidation of the conditions required to produce suitable crystals for x-ray analysis is a significant undertaking. The process for determining suitable conditions generally requires large amounts of both highly skilled labor and highly purified protein.

The application and use of the invention greatly decreases both the quantity of labor and protein required to screen potential crystallization conditions to obtain effective crystallization conditions to provide the suitable high quality crystals required for x-ray crystallography of biomolecules for the use in structure based drug design and the attendant benefits thereof.

The significance of the improvement provided by the invention can be appreciated better in light of what is provided by other state-of-the-art practices

relating to x-ray crystallographic analysis. In particular, the current automated processes, the availability of intense x-radiation from synchrotron sources and improvements in calculating phases, either from molecular replacement or multiple anomalous dispersion (MAD) strategies, all appear able to handle large numbers of crystallized proteins for structure determination. However, none of these aforementioned processes provide the information necessary, or the means, for identifying the proper environmental conditions to form crystals of molecules for growth, diffraction and/or analysis.

The method of the present invention produces a significant aid in determining the conditions suitable for crystallizing proteins, thereby greatly facilitating the production of suitable protein crystals for structural determination without the excessive expenditure of limited resources.

In particular, the presently disclosed method can facilitate a great reduction in the quantity of protein needed for the screening of large numbers of crystallization conditions and the time required to analyze the outcome of each crystallization condition trial. It does so by allowing rapid discrimination between crystals of protein and crystals of other components present in a crystallization trial in very small volumes. Furthermore, the ease in discrimination between protein crystals of interest and crystals of other materials (e.g., salt, buffer, precipitants) is of particular usefulness when the presently disclosed use of dye to distinguish between protein and salt crystals is applied to pico, nano or meso scale crystallization trials performed in a microarray or other micro-device.

In accomplishing the presently disclosed method, the crystallization trials, or necessary parts thereof, can be automated. As the method used to characterize the nature of crystals present does not require physical contact between the crystal of interest and a probe or other such element, as is required for testing of crystals using

conventional means, the method is more amenable to automation than conventional methods now used to determine that a crystal is a protein crystal. Embodiments of the method that are automated are contemplated and provide for the preparation and/or rapid analysis of many samples in high throughput applications.

Automated systems to form solutions for preparing crystallization trials, to conduct trials and to monitor the resulting crystallizations, can include any of those features and aspects as described in U.S. provisional application 60/128,018 and U.S. utility application 09/543,326 both of which are incorporated herein by reference in their entirety. However, the automated systems or components thereof need not include all features described in the previous applications. Minimally, a fully automated system need only include an automated dispensing system to deliver crystallization trial volumes to receptacles, a capability to provide an environment in which crystals can form under at least some conditions, and an ability to detect the presence or absence of formed crystals. The present invention includes the use of dye to facilitate the detection of crystals. Thus, devices of the present invention adapted for automated screening do provide solutions containing the appropriate selected dye and do provide an environment that allows detection of dyed crystals. In one aspect, provision of that environment is effected by use of wells having clear sides or a clear path for optical detection. As will be recognized by one of skill in the art, such an environment need not provide such a clear optical path provided other means for detecting the presence of the dyed crystals is provided. Examples of such other means include, but are not limited to, detectors present within the wells, devices for removal of crystals from wells, and detectors as are known in the art that do not rely upon the presence of a clear optical path, but instead rely on other physical or chemical properties.

In particularly useful embodiments contemplated, the method can include use of an automated system that dispenses the appropriate solutions to form a crystallization trial that includes the presence of a dye useful in the practice of the invention and

overlays the crystallization trial with an oil. Such an automated solution can include a microarray for crystallization trials, an automated dispensing mechanism for dispensing the solutions, an automated dispensing mechanism for dispensing the overlaying oil, and an automated means for detecting crystal growth.

In particularly useful embodiments contemplated, the method can encompass use of an analysis station that detects the color of crystals in samples that are provided to the analysis station in an automated fashion. As will be recognized by those of ordinary skill in the art, detection of crystal color can include the monitoring and detection of selected portions of the spectra of electromagnetic radiation that are absorbed, reflected or transmitted by a crystal, whereby detection of said selected portions of the spectra are indicative of a color.

Such automated methods can further include the sorting of crystals in regard to their determined characteristics. Such sorting can be of a physical nature (i.e., the samples containing the crystals are segregated according to the nature of crystals contained therein) or can be of an informational nature (i.e., the identity of samples containing crystals of a particular nature and/or the location of crystals of a particular nature within a sample are recorded).

Such automated methods can also include determination of the number of crystals or objects of specified character or identity within a given sample, set of samples or other groups. Further, the number and identity relating to obtained crystals can also be used as a descriptor of conditions used to obtain crystals. For example, the total number of biomolecule crystals obtained and/or the fraction of crystals obtained that are biomolecule crystals can be used to describe results obtained using specific sets of conditions that can be used to form crystals of a specified character.

The automated method can monitor samples or crystals within samples. The automated method can operate in response to a predetermined program. The predetermined program can include input or instructions from the user. Input or instructions can be provided prior to the screening process or can be provided during the screening process either in response to queries generated by the predetermined program or by the initiative of the user.

Data obtained from the method can include images and data sets representing images or data derived from both images or selected portions of images. Images can be acquired automatically, with user action or with a combination of both automated and non-automated processes. Particular details regarding details of data analysis and determination of whether a biomolecule or a nonbiomolecule (i.e., a protein crystal or a salt crystal) will, of course, vary depending on the characteristics of the crystallization conditions and the dye being used. Optimization of such particular details are well understood by those of skill in the art and would be recognized not to rise to the level of undue experimentation.

The following examples are put forth so as to provide those of ordinary skill in the art with a complete disclosure and description of how the compounds, compositions, articles, devices and/or methods claimed herein are made and evaluated, and are intended to be purely exemplary of the invention and are not intended to limit the scope of what the inventors regard as their invention. Efforts have been made to ensure accuracy with respect to numbers (e.g., amounts, temperature, etc.), but some errors and deviations should be accounted for. Unless indicated otherwise, parts are parts by weight, temperature is in °C or is at ambient temperature, and pressure is at or near atmospheric.

EXAMPLE ONE

Crystallization of Selected Proteins from Protein Solutions containing Izit.

Introduction

The ability to distinguish between salt and protein crystals has been a problem solved by conventional x-ray crystallographers in a variety of methods. Those methods include the "crush" test whereby a crystal is crushed and determined to be salt if it makes a cracking sound. A second method involves placing the crystal in a x-ray beam and looking for diffraction resolution. A third method includes the addition of a dye composed of methylene blue under the commercial name of Izit to the volume containing a crystal. Theoretically, a crystal of protein contains large channels of solvent and will readily uptake the dye, while a crystal of salt is so well packed that the dye will not be taken up into the salt crystal. Each of these methods has their pros and cons. The crush test con is readily apparent, crush your protein crystal and you're back to the starting point. Mounting crystals and shooting to ascertain their ability to diffract takes a significant amounts of time and effort. The addition of dye to stain protein crystals is clearly useful, even if not 100 % accurate. However, the addition of dye to stain crystals resulting from a crystallization trial cannot be easily used under certain circumstances, particularly those circumstances where small volumes are required.

The process for high through put screening for protein crystallization conditions has been miniaturized which thus improves efficiency, but results in the growth of unmanageably small crystals. The crystals are too small for either the crush test or x-ray analysis, due to difficulty in handling, indeed, even addition of dye to the small volumes and to the small crystals is difficult. A simple solution to the problem, the scaling up of various trials to determine if crystals were salt or protein, results in the creation of a bottleneck for high flux structure determination projects, thus negating one of the primary advantages sought in the miniaturization of the screening process.

Herein, an alternative method of discriminating between protein and salt crystals is disclosed. As described in this example for the purpose of illustration, it includes the addition of a blue dye to crystallization trials of approximately one microliter or lower volumes under paraffin oil as an aid to the detection and the characterization of protein crystals and/or the characterization of crystals as protein crystals.

Materials and Methods:

The proteins screened in this example were: hen egg white lysozyme (Boehringer Mannheim, 1243004), 30 mg/ml in 0.1 M sodium acetate (pH 4.7); thaumatin (Sigma, T7638), 30 mg /ml in 100 mM Tris-HCl (pH 6.5); bovine catalase (Sigma, C40), 30 mg / ml in 50 mM HEPES (pH 7.0); cellulase from *T. viride* (Sigma, C40), 40 mg / ml in 100 mM Tris-HCl (pH 8.5); bovine trypsin (Sigma, T8253), 60 mg / ml in 25 mM HEPES (pH 7.0), 10 mM $CaCl_2$, 10 mg / ml benzamidin HCl; porcine pepsin (Sigma, P6887), 60 mg / ml in 100 mM cacodylate buffer (pH 6.5), 0.2 M Ca acetate; equine serum albumin (Sigma, A3434), 50 mg / ml in 50 mM sodium acetate (pH 5.5); *Bacillus lichenformis* α-amylase (Sigma, A4551), 25 mg / ml in 50 mM cacodylate buffer (pH 6.75), 2 mM $CaCl_2$; Barley β-amylase (Sigma, A7130), 8 mg / ml in 100 mM HEPES (pH 7.5); bovine β-lactoglobulin (Sigma, L3908), 10 mg/ml in 100 mM Tris-HCL (pH 6.5). Precipitants were prepared using reagents from Sigma or Hampton Research. Paraffin oil and Izit were purchased from Hampton Research. Izit is a commercial preparation of methylene blue dye, a planar aromatic dye with a molecular weight of 319 daltons. Crystallization trials were performed in Labsystems 384 clinical plates under 40 µl of paraffin oil. Crystallization buffers used for: lysozyme (100 mM sodium acetate (pH 4.7), 7 % NaCl); thaumatin (1.5 M sodium potassium tartrate); catalase (Crystal Screen 36 (Hampton Research), 100 mM Tris (pH 8.5), 8 % PEG8000)); cellulase (1.4 M ammonium sulfate); trypsin (Crystal Screens 4, 15, 16, 20, 28,30, 31 (Hampton Research), namely for, (4) 0.1 M Tris-HCl (pH 8.5), 2.0 M ammonium sulfate; (15) 0.2 M ammonium sulfate, 0.1 M sodium cacodylate (pH

6.5), 30 % PEG8000; (16) 0.1 M HEPES (pH7.5), 1.5 M lithium sulfate monohydrate; (20) 0.2 M ammonium sulfate, 0.1 M sodium acetate trihydrate (pH 4.6), 25 % PEG4000; (28) 0.2 M sodium acetate trihydrate, 0.1 M sodium cacodylate (pH 6.5), 30 % PEG8000; (30) 0.2 M ammonium sulfate, 30 % PEG8000;(31) 0.2 M ammonium sulfate 30% PEG4000; pepsin, 18 % PEG8000; equine serum albumin, 2.0 M ammonium sulfate; α-amylase, 1 N NaOH; β-amylase, 0.17 M ammonium sulfate, 15 %PEG8000; β-lactoglobulin, 2.0 M ammonium sulfate.

Crystallization trials were initiated by mixing equal portions of protein and precipitant solutions prior to depositing a 0.5 µl protein solution drop in the bottom of a crystallization chamber. Protein solutions were then covered with 40 µl of paraffin oil. The crystallization chambers were left unsealed to incubate at 20 °C. Crystal growth was monitored daily.

Results

The dye added to, and present in, the protein solutions of the nanoliter volume crystallization trials conducted under oil did not appear to diffuse into the paraffin oil. The dye did not stain salt crystals formed during the trials, nor did the presence of the dye interfere with salt crystal formation. As a further control, a 0.5 µl drop of undiluted Izit under 40 µl of paraffin or Al's (Hampton Research) oil was allowed to incubate at 20° C. After 72 hours the dye did not appear to have diffused into the surrounding oils. Even after evaporation of the Al's oil, the blue dye remained in place. As further controls, four 0.5 µl samples of saturated NaCl solution were deposited into four separate containers. In three of these, crystallization trials were initiated with the addition of Izit in quantities of 1 part per 30 parts solution, 1 part per 60 parts solution, and 1 part per 100 parts solutions. Crystals of NaCl were formed under oil in both the absence and the presence of Izit. In none of the trials, under any of the dilutions tested, did the blue dye enter, and thereby color, the salt crystals. As reported, Izit itself will crystallize under conditions of high salt. When this occurs, the crystallized Izit form

distinctive networks of blue fibers or sea urchin crystals. (Note: in Example Three, evidence is presented that suggests that other crystalline forms of Izit or dyed crystals of component(s) can occur. In particular, it is noted that sodium thiocyanate might form dyed crystals under particular conditions.)

For most proteins, the addition of dye to the protein samples tested did not interfere with crystal formation, and furthermore, resulted in the production of colored protein crystals, i.e. the dye was taken up by the protein crystals (Table 1; Figure 1). For each test protein, equal volumes of sample and crystallization buffer were mixed. These crystallization samples were either taken as is, "neat," or Izit was added at a ratio of 1:30, 1:60, or 1:100 in respect to the crystallization sample volume. After preparation of the crystallization samples, the samples were deposited into the crystallization chambers as described in the Materials and Methods section. Crystal trial samples were then covered with 40 µl of paraffin oil and the experiments monitored for the formation of protein crystals. Seven out of ten test proteins crystallized in the absence of dye, specifically, lysozyme, thaumatin, cellulase, pepsin, trypsin, equine serum albumin and catalyse crystals formed in the absence of the blue dye. Each of these test proteins also crystallized in the presence of dye, but crystallization of only four definitively resulted in blue crystals, specifically, lysozyme, thaumatin, trypsin and equine serum albumin. Equine serum albumin displayed phase changes in the absence and presence of dye. Crystallization of cellulase resulted in small flat square plates that appeared to display staining intensity, but it was not possible to definitively characterize the cellulase crystals as blue due to the thinness of the resultant crystals and the resulting similarity of the coloration to the background. The color of cellulase crystals was similar to background hence it was not evident if these crystals absorbed the dye. In addition, characterization of the cellulase crystals was further complicated by their small size. The background intensity due to unincorporated dye present in each sample was similar for each protein tested. The amount of dye incorporated into the protein crystals, and therefore the intensity of

resulting coloration, depended on the concentration of dye used and the number and size of the crystals (Figure 1). The reason(s) for the inability of catalase and pepsin to form crystals in the presence of Izit are unknown. It is reasonable to postulate that the failure of catalase and pepsin crystals to form in the presence of Izit is only isolated to the single set of conditions used in this trial. As evidenced by the results when attempting to crystallize trypsin, alteration of the environmental conditions to which a protein solution is subjected can effect changes in the incorporation of dye into a protein crystal.

The addition of blue dye to micro and even nano crystallization trials under oil, or in a miniaturized crystallization condition screening device, such as a microarray, will provide significant savings in material, time and money. In large part, the savings result from the ability to determine that crystals formed in a miniaturized system, under a specific set of conditions, are protein crystals, without having to replicate the specific set of conditions on a larger scale, thereby negating much of the initial benefit of miniaturization. While this improved method of screening crystallization conditions is by no means a replacement for growing suitable sized crystals for analysis, it offers a significant improvement to the process of determining appropriate conditions to grow the suitable sized crystals required.

EXAMPLE TWO

Screening Crystallization Conditions for Crystallization of Selected Proteins from Protein Solutions containing Izit.

Introduction

The blue dye Izit facilitated the screening of crystallization conditions suitable for producing crystals of lysozyme, pepsin and β-lactoglobulin. The experimental design used in conjunction with the ability to detect nano-scale crystals, facilitated by the use of the dye, allowed 450 different sets of conditions to be screened. This set of trials, performed in duplicate and systematically screening10 variables, consumed only

a few micrograms of protein. Each crystallization variable was represented by several implementations. For example, the variable organic precipitant was represented by five levels: 1, 2-methyl-2,4-pentanediol (MPD); 2, polyethylene glycol 400 (PEG400); 3, PEG2000; 4, PEG4000; and 5, PEG8000. This is in stark contrast to classical approaches normally used in crystallography that use tens of milligrams of protein to screen approximately 24-48 sets of conditions. The ease and economy in which protein crystallization conditions can be screened using these disclosed methods allows a thorough sampling of crystallization parameters for any given protein. This allows an investigator to readily identify conditions optimal for crystallization and can be used to determine conditions suitable for the growth of protein crystals of suitable size and quality for analysis and characterization.

Materials and Methods:

The proteins used as test proteins for this example were: hen egg white lysozyme (Boehringer Mannheim, 1243004), 30 mg/ml in 0.1 M sodium acetate (pH 4.7); porcine pepsin (Sigma, P6887), 60 mg / ml in 100 mM cacodylate buffer (pH 6.5), 0.2 M Ca acetate; bovine β-lactoglobulin (Sigma, L3908), 10 mg/ml in 100 mM Tris-HCL (pH 6.5). The concentrations and buffer solutions used for the nano crystallization screen are identical to those used in the 0.5 µl scale experiments described earlier. Prior to the initiation of the nano crystallization screen IZIT was added to each sample using a dilution of 1 part dye to 19 parts protein (v/v).

Paraffin oil and Izit were purchased from Hampton Research. Nanoliter crystallization screens were initiated by deploying various ratios of protein sample containing blue dye and crystallization buffer (described in Appendix One) into a chamber and then overlaying with 40 µl of Al's oil. The final volume of the experiments were 80 nl. The ratio of protein to precipitating buffer was either 1: 2, 1:1, or 2:1. The exact composition of each of the 450 recipes used is recorded in the table of screen conditions (Appendix One). The pH of the recipes can be calculated using

the Henderson-Hasselback equation. Unless otherwise indicated, the buffer components included in the crystallization trial condition recipes are the base (HEPES and MES). MPD and β-OG are 2-methyl-2,4-pentanediol and N-octyl- β-d-gluocpyranoside. PEG400, PEG2K, PEG4000 and PEG 8K are polyethylene glycols of indicated size/mass as is known to those of skill in the art.

The experimental nanoliter crystallization volumes were sealed during the trials. Data were collected four days after the initiation of the experiment and recorded. The results were scored by visual inspection.

Crystallization trials were conducted using the precipitant solutions described in Appendix one at the ratios indicated. 450 trial conditions, repeated in duplicate, were tested for each of the proteins. The total volume for each trial protein solution was 80 nanoliters at the beginning of the trial. Each volume of protein solution was overlayed with 40 μl of Al's oil. The crystallization chambers were sealed and left to incubate at 4 °C and 20 °C. Crystal growth was recorded on the fourth day.

Results

Conditions which promoted crystallization for each of the three proteins tested were identified. The numbers and types of crystals formed in the trials can be found in Table 2. For each of the three proteins, i.e., lysozyme, pepsin and β-lactoglobulin, there were 900 total trial results (450 trial screening conditions performed in duplicate). Results for each trial, i.e., each separate volume of protein solution, were analyzed and categorized. These categories include: (1) a clear drop, (2) phase separation, (3) precipitate (regular, granular), (4) microcrystals/precipitate, (5) rosettes or spherulites, (6) needles (one-dimensional growth), (7) plates (two-dimensional growth), (8) small crystals (three-dimensional growth of less than 0.2 mm) and (9) crystals (three-dimensional growth of greater than 0.2 mm). The categories or scores used for the nanoliter crystallization trials were adopted from those suggested by Hampton

Research. Scoring of individual experiments to assign each to a category was performed by visual inspection. As the titles of the categories suggest, the results of each experiment were scored based upon presence or absence of detectable species and upon the species' morphology. For example, needle-like crystals are those appear to have one axis that is very long compared to the others, while plates have two axes of approximately equivalent size, each significantly larger than the third. A three dimensional crystal appears to have growth in three dimensions and looks like a brick. For the other categories, precipitate looks like sand, while both phase separations and rosettes look like mixtures of oil and water. The rosettes usually appear to have dense staining in their centers. In some instances, there is greater ambiguity as to the proper categorical assignment. In addition, the total number of trials in which blue crystals formed is also indicated. The number of blue crystals is calculated from visual inspection of categories 6 – 9, i.e., needles, plates, small three dimensional crystals and larger three dimensional crystals. A representative micrograph of blue crystals formed from each of the three proteins screened is shown in Figures 2-4. Specifically: Figure 2 shows a blue lysozyme crystal grown in the presence of Izit using screening condition 361; Figure 3 shows a blue pepsin crystal grown in the presence of Izit using screening condition 75; and Figure 4 shows a blue β-lactoglobulin crystal grown in the presence of Izit using screening condition 213.

EXAMPLE THREE

Screening Crystallization Conditions for Crystallization of Selected Proteins from Protein Solutions containing Izit and Controls.

Methods similar to those described in Example 2 were used to test the method of the invention using additional proteins and conditions. Figure 5 shows micrographs of these trials wherein proteins, buffer, conditions and dye were varied in character and quantity. Trials were conducted as described before and using the noted screening Expt. # [Stock] conditions outlined in Appendix One. In the following example; T1=4 °C, T2=15 °C, and T3=22 °C.

Crystallization conditions using Izit dye w/o any added protein were examined. For example, screening conditions 251 (at T3), 254 (at T3), 285 (at T2), 266 (at T3) and 339 (at T3) were conducted. Results from conditions 251, 285, 266, and 339 are shown in Figure 5A, B, C, and D, respectively. Condition 254, results not shown, resulted in no observable precipitation or crystallization. Condition 251 (Figure 5A) also does not result in any observable crystal formation. However, condition 285, which includes acetate buffer at pH 4.5, 42 mM Ammonium Sulfate, 3.7% MPD, 1% glycerol and 2 mM magnesium chloride, and condition 339, which includes acetate buffer at pH 4.5, 460 mM thiocyanate, 0.8% PEG 8000, 0.5% glycerol and 8 mM arginine-HCl, both result in apparent crystals.

Crystallization conditions with various proteins were also examined. Figure 5E and 5F show results from β-lactoglobulin under conditions with phosphate buffer at pH 8 and with PEG 400 (at T1) and with phosphate buffer at pH 6, PEG 8000, 10% glycerol, 0.008M Arg-HCl (at T3), respectively. Figure 5G, 5H, and 5I show results from myristol transferase under conditions 291 (at T3), 197 (at T2) and 259 (at T3), respectively. Figure 5J shows results from pepsin under condition 347 (at T3). Figures 5K and 5L show results from Renac2 under conditions 41 (at T1) and 339 (at T3), respectively. Figures 5M and 5N show results from Rob1 under conditions 212 (at T2) and 337 (at T3), respectively. Figure 5O shows results from B10 in acetate buffer at pH 4.5, with 450 mM thiocyanate, 0.8% PEG 8000, 0.5% glycerol and 8 mM arginine HCl (at T3).

Throughout this application, various publications are referenced. The disclosures of these publications in their entireties are hereby incorporated by reference into this application in order to more fully describe the state of the art to which this invention pertains.

It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the scope or spirit of the invention. Other embodiments of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. It is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the invention being indicated by the following claims.

Table 1

Summary of IZIT Crystallization Results

Protein	Neat	30	60	5500	Condition	Initial pH
Lysozyme	Xtl	Bxtl	Bxtl	Bxtl		4.7
Thaumatin	Xtl	Bxtl	Bxtl	Bxtl	HR	6.5
Catalase	Xtl	-	-	-	CS36	8.0
Cellulase	Xtl	Xtl	Xtl	Xtl		8.5
Pepsin	Xtl	-	-	-		6.5
Equine serum albumin	Pc	BPc	BPc	BPc		5.5
α-amylase	-	-	-	-		7.0
β-amylase	-	-	-	-		7.5
β-lactoglobulin	-	-	-	-		6.5
Trypsin	Xtl	Bxtl	Bxtl	Bxtl	CS4	7.0
Trypsin	Xtl	Xtl	Xtl	Xtl	CS15	7.0
Typsin	Xtl	Bxtl	Bxtl	Bxtl	CS16	7.0
Trypsin	Xtl	Xtl	Xtl	Xtl	CS20	7.0

Protein	Neat	1:30	1:60	1:100	Condition	mini pH
Trypsin	Xtl	Xtl	Xtl	Xtl	CS28	7.0
Trypsin	Xtl	Xtl	Xtl	Xtl	CS30	7.0
Trypsin	Xtl	Xtl	Xtl	Xtl	31	7.0

Xtl = crystal, Bxtl = blue crystal, Pc = phase change, BPc = blue phase change, neat = absence of Izit in crystallization trial. Condition = the crystallization buffer used. CS = crystal screen. HR = Hampton Research web page http://www.hamptonresearch.com/.

Table 2A
Lysozyme

Score	Frequency
1	795
2	58
3	17
4	3
5	1
6	4
7	1
8	21
Number of blue crystals	10

Table 2B
Pepsin

Score	Frequency
1	591
2	24
3	30
4	9
5	0
6	25
7	164

8	57
Number of blue crystals	2

Table 2C
β-Lactoglobulin

Score	Frequency
1	807
2	58
3	8
4	13
5	1
6	5
7	7
8	1
Number of blue crystals	5

1 Score Definitions

Score	Score Description
1	Clear Drop
2	Phase Separation
3	Precipitate (Regular Granular)
4	MicroCrystals / Precipitate
5	Rosettes or Spherulites
6	Needles (1D Growth)
7	Plates (2D Growth)
8	Crystals (3D Growth < 0.2mm)
9	Crystals (3D Growth > 0.2mm)

Code Expt # [Stock]	1 MES [0.5M]	4 HEPES [0.5M]	1 Sodium Hydroxide [2M]	1 Sodium Chloride [2M]	2 Citric Acid [2M]	3 Acetic Acid [2M]	4 Ammonium Sulfate [2M]	5 Monosodium Phosphate [2M]	1 MPD [30%]	2 PEG 400 [30%]	3 PEG 2K [30%]	4 PEG 4000 [30%]	5 PEG 8K [30%]	2 MgCl2 [0.2M]	3 CaCl2 [0.2M]	2 Arginine-HCl [0.5M]	3 Beta-OG [0.5%]	1 Glycerol [75% w/v]	1 Water	Total	Recipe dispensed	Protein dispensed
1	62	0	9	0	0	0	0	40	203	0	0	0	0	0	0	0	31	41	614	1000	3	1
2	0	62	83	0	0	0	0	114	0	0	0	125	0	0	0	31	0	0	585	1000	3	1
3	62	0	11	48	0	0	0	0	0	0	0	0	240	15	0	0	31	41	552	1000	3	1
4	0	62	215	0	75	0	0	0	0	0	0	83	0	0	15	31	0	21	499	1000	3	1
5	62	0	151	0	0	152	0	0	14	0	0	0	0	0	15	0	0	41	566	1000	3	1
6	62	0	204	0	75	0	0	0	0	83	0	0	0	0	15	0	31	21	509	1000	3	1
7	62	0	7	121	0	0	0	0	0	0	0	0	11	0	0	0	31	41	729	1000	3	1
8	62	0	11	40	0	0	0	0	0	0	0	196	0	0	0	0	31	21	641	1000	3	1
9	0	62	4	115	0	0	0	0	0	0	0	0	127	15	0	31	0	21	626	1000	3	1
10	62	0	301	0	152	0	0	0	0	13	0	0	0	15	0	0	31	41	385	1000	3	1
11	0	62	51	0	0	39	0	0	0	0	0	194	0	15	0	0	31	0	608	1000	3	1
12	0	62	8	0	0	0	149	0	0	13	0	0	0	15	15	0	0	0	753	1000	3	1
13	62	0	11	182	0	0	0	0	0	0	0	0	0	0	0	0	0	21	694	1000	3	1
14	0	62	98	0	0	95	0	0	0	105	0	0	16	15	0	0	31	21	573	1000	3	1
15	0	62	4	0	0	0	182	0	0	0	16	0	0	15	15	0	0	21	701	1000	3	1
16	0	62	39	0	0	0	0	48	244	0	0	0	0	0	0	31	0	21	556	1000	3	1
17	0	62	94	0	0	0	0	95	0	0	108	0	0	0	0	0	31	21	591	1000	3	1
18	62	0	40	0	0	0	0	181	16	0	0	0	0	0	0	0	31	0	670	1000	3	1
19	62	0	43	0	0	43	0	0	0	0	0	235	0	0	15	0	31	0	566	1000	3	1
20	0	62	47	0	0	0	0	114	0	0	129	0	0	0	0	31	0	0	617	1000	3	1
21	62	0	7	0	0	0	0	183	0	16	0	0	0	0	0	0	31	0	661	1000	3	1
22	0	62	164	0	0	152	0	0	0	0	14	0	0	15	0	31	0	41	522	1000	3	1
23	62	0	3	0	0	0	96	0	0	106	0	0	0	0	0	31	0	41	661	1000	3	1
24	62	0	37	0	0	40	0	0	0	197	0	0	0	15	0	31	0	21	598	1000	3	1
25	62	0	3	40	0	0	0	0	0	0	0	197	0	0	15	0	31	41	611	1000	3	1
26	62	0	124	0	0	115	0	0	0	0	0	0	127	0	15	0	0	21	536	1000	3	1
27	62	0	105	0	0	96	0	0	0	0	0	0	106	0	0	0	0	41	590	1000	3	1
28	62	0	7	96	0	0	0	0	0	106	0	0	0	0	15	0	0	41	642	1000	3	1
29	62	0	17	0	0	0	0	182	0	0	0	16	0	0	0	31	0	21	672	1000	3	1
30	0	62	4	116	0	0	0	0	131	0	0	0	0	0	0	0	0	41	647	1000	3	1
31	0	62	4	0	0	0	161	0	0	0	0	0	16	0	0	0	0	0	738	1000	3	1
32	62	0	11	48	0	0	0	0	0	237	0	0	0	0	15	0	0	0	628	1000	3	1
33	62	0	7	0	0	0	115	0	0	0	0	126	0	0	0	0	31	21	639	1000	3	1
34	0	62	104	0	0	96	0	0	0	0	0	0	106	15	0	0	31	41	546	1000	3	1
35	0	62	127	0	0	0	0	181	0	0	0	16	0	0	0	0	31	0	584	1000	3	1

36	0	62	142	0	0	0	0	152	0	13	0	0	0	0	0	0	0	41	590	1000	3	1
37	62	0	130	0	0	149	0	0	0	0	0	0	13	0	0	0	31	0	615	1000	3	1
38	0	62	8	0	0	0	118	0	0	0	11	0	0	0	15	31	0	0	756	1000	3	1
39	0	62	87	0	0	75	0	0	85	0	0	0	0	15	0	0	0	21	655	1000	3	1
40	0	62	107	0	0	0	0	151	0	0	0	0	13	0	0	31	0	21	616	1000	3	1
41	0	62	8	0	0	0	151	0	0	13	0	0	0	15	0	0	31	21	700	1000	3	1
42	62	0	7	149	0	0	0	0	0	0	0	13	0	0	15	0	0	0	754	1000	3	1
43	0	62	92	0	31	0	0	0	0	156	0	0	0	0	15	0	31	21	592	1000	3	1
44	0	62	84	0	0	76	0	0	0	84	0	0	0	0	15	0	0	41	638	1000	3	1
45	62	0	11	0	0	0	75	0	0	0	0	0	83	15	0	31	0	21	702	1000	3	1
46	62	0	354	0	152	0	0	0	0	0	0	13	0	0	0	31	0	41	347	1000	3	1
47	0	62	12	0	0	0	48	0	0	0	246	0	0	15	0	0	31	41	546	1000	3	1
48	62	0	164	0	76	0	0	0	0	0	86	0	0	15	0	31	0	41	525	1000	3	1
49	62	0	9	0	0	0	0	32	0	158	0	0	0	0	0	31	0	41	668	1000	3	1
50	62	0	112	0	40	0	0	0	202	0	0	0	0	15	0	31	0	21	518	1000	3	1
51	0	73	151	0	49	0	0	0	0	242	0	0	0	0	0	0	36	0	449	1000	3	1
52	73	0	75	0	30	0	0	0	0	0	150	0	0	0	0	0	36	24	611	1000	3	1
53	73	0	197	0	72	0	0	0	0	0	0	0	79	18	0	0	36	48	477	1000	3	1
54	0	73	193	0	0	185	0	0	0	0	0	16	0	0	18	0	36	0	479	1000	3	1
55	0	73	9	30	0	0	0	0	0	149	0	0	0	0	0	36	0	48	655	1000	3	1
56	0	73	4	49	0	0	0	0	251	0	0	0	0	0	0	36	0	48	537	1000	3	1
57	0	73	9	0	0	0	29	0	0	0	0	0	145	0	18	0	36	0	690	1000	3	1
58	73	0	8	95	0	0	0	0	0	0	108	0	0	0	18	36	0	48	613	1000	3	1
59	73	0	18	0	0	0	0	29	0	0	148	0	0	0	0	0	36	0	696	1000	3	1
60	73	0	223	0	94	0	0	0	106	0	0	0	0	0	18	0	36	24	425	1000	3	1
61	0	73	87	0	30	0	0	0	0	0	0	0	147	0	0	0	0	24	640	1000	3	1
62	0	73	127	0	0	114	0	0	0	10	0	0	0	0	0	0	36	48	591	1000	3	1
63	0	73	4	151	0	0	0	0	0	0	0	13	0	0	0	36	0	48	674	1000	3	1
64	0	73	161	0	49	0	0	0	0	0	0	244	0	0	0	36	0	48	389	1000	3	1
65	73	0	13	188	0	0	0	0	0	16	0	0	0	0	0	0	0	48	662	1000	3	1
66	0	73	9	0	0	0	119	0	0	0	0	130	0	0	0	0	36	48	585	1000	3	1
67	0	73	53	0	0	49	0	0	0	0	249	0	0	18	0	0	0	24	533	1000	3	1
68	0	73	143	0	49	0	0	0	0	0	0	0	246	18	0	0	0	48	423	1000	3	1
69	0	73	4	0	0	0	148	0	0	13	0	0	0	18	0	0	0	0	744	1000	3	1
70	73	0	13	0	0	0	112	0	0	0	0	0	10	0	18	36	0	24	714	1000	3	1
71	73	0	8	149	0	0	0	0	0	0	0	0	13	0	18	0	36	24	678	1000	3	1
72	0	73	49	0	0	0	0	118	0	0	0	129	0	0	0	0	0	24	607	1000	3	1
73	0	73	132	0	40	0	0	0	0	0	0	196	0	18	0	0	36	48	457	1000	3	1
74	0	73	120	0	0	111	0	0	0	0	10	0	0	18	0	0	0	0	669	1000	3	1
75	0	73	4	94	0	0	0	0	0	104	0	0	0	18	0	0	36	24	646	1000	3	1
76	0	73	14	0	0	0	70	0	0	0	0	0	77	0	0	36	0	0	730	1000	3	1
77	73	0	132	0	0	151	0	0	13	0	0	0	0	18	0	0	36	48	529	1000	3	1
78	0	73	116	0	0	112	0	0	0	10	0	0	0	0	18	36	0	24	611	1000	3	1
79	73	0	6	0	0	0	0	118	0	0	0	0	130	0	0	0	0	24	649	1000	3	1
80	73	0	14	0	0	0	0	94	0	0	107	0	0	0	0	0	0	24	689	1000	3	1
81	0	73	9	0	0	0	70	0	79	0	0	0	0	0	0	0	36	0	733	1000	3	1
82	0	73	4	186	0	0	0	0	17	0	0	0	0	18	0	0	0	24	678	1000	3	1

83	73	0	129	0	0	148	0	0	0	0	0	0	13	0	0	36	0	0	601	1000	3	1
84	0	73	4	0	0	0	39	0	0	0	200	0	0	18	0	0	36	24	605	1000	3	1
85	0	73	14	30	0	0	0	0	0	149	0	0	0	0	0	36	0	48	650	1000	3	1
86	73	0	75	0	30	0	0	0	0	0	0	0	147	0	0	0	0	24	651	1000	3	1
87	73	0	19	0	0	0	0	39	198	0	0	0	0	0	0	0	0	0	671	1000	3	1
88	73	0	42	0	0	30	0	0	0	0	0	148	0	18	0	36	0	48	604	1000	3	1
89	0	73	158	0	49	0	0	0	0	0	0	0	242	0	0	36	0	0	442	1000	3	1
90	73	0	89	0	30	0	0	0	152	0	0	0	0	0	18	36	0	48	553	1000	3	1
91	0	73	14	119	0	0	0	0	0	0	134	0	0	0	0	0	36	48	576	1000	3	1
92	73	0	65	0	0	72	0	0	81	0	0	0	0	0	0	0	36	48	625	1000	3	1
93	0	73	152	0	49	0	0	0	0	0	0	0	244	0	18	36	0	24	403	1000	3	1
94	0	73	9	29	0	0	0	0	0	145	0	0	0	0	0	0	0	0	744	1000	3	1
95	73	0	203	0	94	0	0	0	106	0	0	0	0	0	0	0	36	24	463	1000	3	1
96	73	0	43	0	0	0	0	186	0	0	17	0	0	0	0	0	36	24	620	1000	3	1
97	0	73	9	0	0	0	117	0	0	0	0	0	129	0	18	36	0	0	618	1000	3	1
98	0	73	14	0	0	0	148	0	13	0	0	0	0	0	0	0	0	0	753	1000	3	1
99	73	0	13	0	0	0	49	0	0	246	0	0	0	0	18	36	0	48	516	1000	3	1
100	73	0	148	0	0	148	0	0	13	0	0	0	0	0	0	36	0	0	582	1000	3	1
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102	0	100	6	167	0	0	0	0	0	0	15	0	0	25	0	50	0	67	570	1000	2	2
103	0	100	33	0	0	0	0	31	0	0	156	0	0	0	0	50	0	67	564	1000	2	2
104	0	100	50	0	0	0	0	114	0	0	0	10	0	0	0	0	50	33	643	1000	2	2
105	100	0	21	0	0	0	0	167	0	0	15	0	0	0	0	0	50	67	580	1000	2	2
106	0	100	322	0	106	0	0	0	0	0	0	0	117	0	0	0	0	67	269	1000	2	2
107	100	0	54	0	0	57	0	0	292	0	0	0	0	25	0	0	0	67	405	1000	2	2
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110	100	0	61	0	0	44	0	0	224	0	0	0	0	0	0	0	50	67	454	1000	2	2
111	100	0	18	0	0	0	135	0	0	0	153	0	0	0	0	50	0	0	544	1000	2	2
112	0	100	6	0	0	0	31	0	0	0	156	0	0	0	0	0	0	67	641	1000	2	2
113	100	0	27	0	0	0	0	57	289	0	0	0	0	0	0	0	50	33	443	1000	2	2
114	100	0	296	0	138	0	0	0	156	0	0	0	0	0	0	0	50	67	194	1000	2	2
115	100	0	129	0	43	0	0	0	0	0	0	0	216	25	0	50	0	33	403	1000	2	2
116	100	0	18	0	0	0	167	0	0	0	0	0	15	0	25	50	0	67	559	1000	2	2
117	100	0	11	114	0	0	0	0	0	0	0	10	0	25	0	50	0	33	656	1000	2	2
118	100	0	5	104	0	0	0	0	0	115	0	0	0	0	25	0	50	33	567	1000	2	2
119	0	100	6	218	0	0	0	0	19	0	0	0	0	0	25	0	0	67	565	1000	2	2
120	0	100	41	0	0	0	0	43	221	0	0	0	0	0	0	50	0	33	511	1000	2	2
121	100	0	18	0	0	0	136	0	0	0	154	0	0	0	25	50	0	33	483	1000	2	2
122	100	0	163	0	57	0	0	0	289	0	0	0	0	25	0	50	0	33	282	1000	2	2
123	100	0	232	0	0	218	0	0	0	0	0	0	0	25	0	0	0	67	339	1000	2	2
124	100	0	111	0	0	106	0	0	0	0	0	116	19	0	25	0	50	67	426	1000	2	2
125	0	100	163	0	0	0	0	167	15	0	0	0	0	0	0	50	0	67	438	1000	2	2
126	0	100	41	0	0	0	0	43	218	0	0	0	0	0	0	0	50	0	548	1000	2	2
127	100	0	53	0	0	44	0	0	0	0	224	0	0	25	0	50	0	67	437	1000	2	2
128	0	100	19	0	0	0	56	0	0	0	287	0	0	25	0	0	0	0	513	1000	2	2
129	100	0	37	0	0	0	0	116	0	0	0	10	0	0	0	50	0	67	620	1000	2	2

130	100	0	142	0	57	0	0	0	0	0	292	0	0	0	25	0	50	67	266	1000	2	2
131	0	100	429	0	138	0	0	0	0	0	0	151	0	25	0	0	50	67	40	1000	2	2
132	100	0	96	0	31	0	0	0	0	152	0	0	0	25	0	50	0	67	479	1000	2	2
133	0	100	294	0	103	0	0	0	0	0	117	0	0	0	25	0	50	0	311	1000	2	2
134	100	0	18	138	0	0	0	0	0	0	156	0	0	0	25	0	0	67	497	1000	2	2
135	0	100	6	57	0	0	0	0	292	0	0	0	0	0	0	50	0	67	428	1000	2	2
136	0	100	88	0	0	0	0	214	19	0	0	0	0	0	0	0	0	0	579	1000	2	2
137	100	0	11	0	0	0	73	0	0	0	0	81	0	25	0	50	0	67	593	1000	2	2
138	0	100	172	0	0	167	0	0	0	0	15	0	0	0	0	0	50	67	429	1000	2	2
139	100	0	24	0	0	0	0	216	0	19	0	0	0	0	0	50	0	33	558	1000	2	2
140	100	0	11	116	0	0	0	0	0	0	0	10	0	25	0	50	0	67	621	1000	2	2
141	100	0	52	0	0	43	0	0	0	216	0	0	0	25	0	0	50	33	480	1000	2	2
142	0	100	662	0	216	0	0	0	19	0	0	0	0	0	0	50	0	33	81	1000	2	2
143	100	0	11	0	0	0	116	0	0	0	10	0	0	25	0	50	0	67	621	1000	2	2
144	100	0	140	0	0	136	0	0	0	0	0	150	0	0	25	0	50	33	365	1000	2	2
145	0	100	347	0	114	0	0	0	0	0	0	10	0	0	0	0	50	33	345	1000	2	2
146	0	100	6	0	0	0	112	0	0	0	0	10	0	25	0	0	50	0	697	1000	2	2
147	100	0	5	0	0	0	138	0	0	0	0	0	152	0	0	50	0	67	488	1000	2	2
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151	0	62	51	0	0	48	0	0	0	238	0	0	0	0	15	0	31	21	534	1000	3	1
152	62	0	4	0	0	0	0	40	0	0	202	0	0	0	0	0	31	21	642	1000	3	1
153	62	0	3	0	0	0	118	0	0	0	0	10	0	0	0	31	0	0	776	1000	3	1
154	0	62	191	0	0	183	0	0	0	0	16	0	0	15	0	0	0	41	492	1000	3	1
155	62	0	7	0	0	0	116	0	131	0	0	0	0	0	0	31	0	41	613	1000	3	1
156	0	62	12	0	0	0	40	0	0	197	0	0	0	0	15	31	0	21	623	1000	3	1
157	62	0	11	151	0	0	0	0	0	0	0	0	13	15	0	0	0	21	728	1000	3	1
158	0	62	12	0	0	0	121	0	11	0	0	0	0	15	0	0	31	41	708	1000	3	1
159	0	62	361	0	121	0	0	0	0	0	11	0	0	0	15	0	31	41	359	1000	3	1
160	62	0	7	0	0	0	181	0	0	0	0	16	0	15	0	31	0	0	689	1000	3	1
161	0	62	4	0	0	0	48	0	245	0	0	0	0	0	0	0	0	41	600	1000	3	1
162	0	62	236	0	75	0	0	0	0	0	0	83	0	0	15	31	0	21	478	1000	3	1
163	62	0	202	0	75	0	0	0	84	0	0	0	0	15	0	31	0	0	532	1000	3	1
164	0	62	12	116	0	0	0	0	131	0	0	0	0	0	15	0	0	41	624	1000	3	1
165	0	62	101	0	32	0	0	0	0	158	0	0	0	0	0	0	31	41	576	1000	3	1
166	62	0	16	0	0	0	0	31	0	156	0	0	0	0	0	0	0	21	714	1000	3	1
167	0	62	4	114	0	0	0	0	0	0	0	125	0	0	0	0	31	0	665	1000	3	1
168	0	62	123	0	0	116	0	0	0	128	0	0	0	0	15	0	0	41	515	1000	3	1
169	62	0	11	31	0	0	0	0	0	0	158	0	0	0	15	0	31	0	692	1000	3	1
170	0	62	12	0	0	0	94	0	0	0	0	104	0	15	0	31	0	0	683	1000	3	1
171	0	62	12	95	0	0	0	0	0	0	0	0	105	15	0	0	31	21	660	1000	3	1
172	0	62	12	0	0	0	75	0	0	83	0	0	0	0	0	0	0	0	770	1000	3	1
173	0	62	55	0	0	48	0	0	242	0	0	0	0	15	0	0	31	0	548	1000	3	1
174	0	62	357	0	119	0	0	0	11	0	0	0	0	0	0	0	0	21	431	1000	3	1
175	0	62	8	119	0	0	0	0	11	0	0	0	0	15	0	0	31	21	734	1000	3	1
176	62	0	104	0	48	0	0	0	0	0	0	0	237	0	0	0	31	0	520	1000	3	1

177	0	62	8	0	0	0	152	0	14	0	0	0	0	0	0	0	31	41	693	1000	3	1
178	62	0	179	0	75	0	0	0	85	0	0	0	0	0	15	0	0	21	563	1000	3	1
179	0	62	8	75	0	0	0	0	0	0	84	0	0	15	0	0	31	0	726	1000	3	1
180	62	0	296	0	149	0	0	0	0	0	0	0	13	15	0	0	31	0	434	1000	3	1
181	0	62	157	0	0	149	0	0	0	0	0	13	0	0	0	0	31	0	588	1000	3	1
182	62	0	97	0	40	0	0	0	0	0	0	0	197	0	15	31	0	21	537	1000	3	1
183	0	62	28	0	0	0	0	31	0	0	0	0	155	0	0	0	31	0	694	1000	3	1
184	0	62	46	0	0	0	0	40	203	0	0	0	0	0	0	0	31	41	577	1000	3	1
185	62	0	204	0	95	0	0	0	0	0	0	0	105	15	0	31	0	21	467	1000	3	1
186	62	0	85	0	0	75	0	0	0	83	0	0	0	0	0	0	31	21	643	1000	3	1
187	0	62	12	95	0	0	0	0	108	0	0	0	0	0	15	31	0	21	657	1000	3	1
188	62	0	307	0	116	0	0	0	131	0	0	0	0	0	0	31	0	41	313	1000	3	1
189	0	62	94	0	0	0	0	96	0	0	0	0	106	0	0	0	0	41	601	1000	3	1
190	62	0	3	116	0	0	0	0	131	0	0	0	0	0	15	0	0	41	632	1000	3	1
191	62	0	5	0	0	0	0	75	0	0	85	0	0	0	0	31	0	21	722	1000	3	1
192	0	62	87	0	0	0	0	121	11	0	0	0	0	0	0	0	0	41	679	1000	3	1
193	0	62	98	0	0	94	0	0	0	0	107	0	0	0	15	31	0	0	594	1000	3	1
194	62	0	7	0	0	0	0	181	0	0	0	0	16	0	0	0	31	0	705	1000	3	1
195	0	62	62	0	0	0	0	152	14	0	0	0	0	0	0	0	0	41	670	1000	3	1
196	0	62	4	182	0	0	0	0	0	0	0	16	0	15	0	0	0	21	701	1000	3	1
197	0	62	8	0	0	0	39	0	200	0	0	0	0	0	0	0	0	0	691	1000	3	1
198	62	0	131	0	0	151	0	0	0	0	0	0	13	0	15	0	0	21	608	1000	3	1
199	0	62	154	0	48	0	0	0	0	0	0	237	0	0	15	31	0	21	433	1000	3	1
200	0	62	87	0	0	0	0	121	0	0	0	0	11	0	0	0	0	41	679	1000	3	1
201	0	73	14	118	0	0	0	0	133	0	0	0	0	0	18	36	0	24	564	1000	3	1
202	0	73	32	0	0	0	0	72	0	0	0	0	79	0	0	36	0	48	660	1000	3	1
203	73	0	29	0	0	0	0	95	108	0	0	0	0	0	0	0	0	48	648	1000	3	1
204	0	73	56	0	0	0	0	49	0	0	0	0	242	0	0	0	0	0	581	1000	3	1
205	0	73	113	0	39	0	0	0	198	0	0	0	0	18	0	36	0	0	523	1000	3	1
206	73	0	21	0	0	0	0	49	0	242	0	0	0	0	0	36	0	0	580	1000	3	1
207	73	0	128	0	0	117	0	0	0	0	0	0	129	18	0	36	0	0	500	1000	3	1
208	0	73	61	0	0	0	0	149	0	0	0	13	0	0	0	0	0	24	680	1000	3	1
209	0	73	563	0	185	0	0	0	0	0	0	16	0	0	0	36	0	0	127	1000	3	1
210	73	0	138	0	49	0	0	0	0	0	249	0	0	18	0	0	0	24	448	1000	3	1
211	0	73	9	185	0	0	0	0	0	0	16	0	0	0	0	0	0	0	717	1000	3	1
212	0	73	75	0	0	0	0	185	0	0	0	0	16	0	0	0	36	0	615	1000	3	1
213	0	73	214	0	70	0	0	0	0	0	79	0	0	18	0	36	0	0	510	1000	3	1
214	73	0	8	186	0	0	0	0	0	0	17	0	0	0	18	36	0	24	638	1000	3	1
215	0	73	14	0	0	0	111	0	0	10	0	0	0	0	18	0	36	0	739	1000	3	1
216	0	73	40	0	0	0	0	94	0	0	0	0	104	0	0	0	36	24	628	1000	3	1
217	73	0	10	0	0	0	0	40	0	0	0	196	0	0	0	0	0	48	633	1000	3	1
218	0	73	462	0	151	0	0	0	13	0	0	0	0	0	0	0	36	48	216	1000	3	1
219	73	0	4	0	0	0	0	30	0	0	150	0	0	0	0	36	0	24	683	1000	3	1
220	73	0	120	0	0	119	0	0	0	0	0	0	131	18	0	0	36	48	454	1000	3	1
221	73	0	299	0	151	0	0	0	0	0	0	0	13	18	0	0	0	48	398	1000	3	1
222	0	73	14	30	0	0	0	0	0	0	0	148	0	0	0	36	0	48	651	1000	3	1
223	73	0	8	0	0	0	95	0	0	0	0	104	0	18	0	0	0	46	653	1000	3	1

224	73	0	10	0	0	0	0	29	0	0	0	0	145	0	0	0	0	0	744	1000	3	1
225	0	73	462	0	151	0	0	0	0	0	13	0	0	0	0	36	0	48	216	1000	3	1
226	73	0	197	0	72	0	0	0	0	0	0	79	0	0	18	0	0	48	514	1000	3	1
227	0	73	549	0	185	0	0	0	0	16	0	0	0	0	0	0	36	0	141	1000	3	1
228	0	73	9	0	0	0	185	0	0	0	0	16	0	0	18	0	36	0	663	1000	3	1
229	0	73	446	0	149	0	0	0	0	0	0	0	13	0	0	36	0	24	259	1000	3	1
230	0	73	19	0	0	0	0	39	0	0	200	0	0	0	0	36	0	24	608	1000	3	1
231	73	0	112	0	39	0	0	0	198	0	0	0	0	18	0	0	0	0	560	1000	3	1
232	0	73	189	0	0	186	0	0	17	0	0	0	0	0	18	0	36	24	456	1000	3	1
233	0	73	124	0	0	111	0	0	0	10	0	0	0	0	18	0	0	0	664	1000	3	1
234	73	0	43	0	0	0	0	186	0	16	0	0	0	0	0	36	0	24	621	1000	3	1
235	73	0	311	0	117	0	0	0	132	0	0	0	0	0	18	36	0	0	313	1000	3	1
236	0	73	100	0	29	0	0	0	0	0	0	144	0	18	0	0	0	0	636	1000	3	1
237	0	73	9	0	0	0	93	0	0	0	0	102	0	0	18	36	0	0	668	1000	3	1
238	0	73	282	0	93	0	0	0	0	103	0	0	0	0	18	0	0	0	431	1000	3	1
239	73	0	66	0	30	0	0	0	0	0	0	146	0	0	18	0	0	24	644	1000	3	1
240	0	73	140	0	49	0	0	0	0	242	0	0	0	0	0	0	36	0	460	1000	3	1
241	0	73	4	71	0	0	0	0	0	0	0	78	0	18	0	0	0	24	732	1000	3	1
242	0	73	94	0	0	0	0	93	0	103	0	0	0	0	0	0	36	0	600	1000	3	1
243	0	73	23	0	0	0	0	49	0	0	0	240	0	0	0	0	0	0	616	1000	3	1
244	73	0	252	0	118	0	0	0	0	0	0	129	0	0	18	0	0	24	386	1000	3	1
245	73	0	46	0	0	40	0	0	0	197	0	0	0	0	18	36	0	48	542	1000	3	1
246	73	0	28	0	0	0	0	93	0	0	0	102	0	0	0	0	0	0	704	1000	3	1
247	0	73	29	0	0	0	0	30	0	0	0	0	149	0	0	0	0	48	671	1000	3	1
248	0	73	74	0	0	70	0	0	0	0	79	0	0	18	0	36	0	0	650	1000	3	1
249	73	0	4	0	0	0	118	0	0	0	0	129	0	18	0	0	36	24	598	1000	3	1
250	0	73	74	0	0	70	0	0	0	77	0	0	0	0	18	0	36	0	652	1000	3	1
251	100	0	120	0	0	104	0	0	118	0	0	0	0	0	0	50	0	33	474	1000	2	2
252	100	0	11	0	0	0	116	0	0	0	0	10	0	0	0	0	0	67	696	1000	2	2
253	100	0	11	112	0	0	0	0	0	0	0	10	0	0	0	0	50	0	717	1000	2	2
254	100	0	119	0	0	103	0	0	0	114	0	0	0	0	0	50	0	0	514	1000	2	2
255	100	0	18	0	0	0	57	0	0	0	290	0	0	25	0	0	0	33	477	1000	2	2
256	100	0	5	0	0	0	112	0	0	0	0	0	10	0	0	0	50	0	723	1000	2	2
257	0	100	6	0	0	0	214	0	0	0	19	0	0	25	0	50	0	0	586	1000	2	2
258	100	0	5	73	0	0	0	0	0	81	0	0	0	0	25	50	0	67	599	1000	2	2
259	100	0	5	0	0	0	57	0	0	0	0	0	283	25	0	0	0	33	497	1000	2	2
260	100	0	14	0	0	0	0	44	0	219	0	0	0	0	0	0	0	67	557	1000	2	2
261	0	100	135	0	0	0	0	135	153	0	0	0	0	0	0	50	0	0	427	1000	2	2
262	100	0	11	0	0	0	114	0	0	10	0	0	0	0	0	0	50	33	681	1000	2	2
263	100	0	19	0	0	0	0	138	0	0	0	0	152	0	0	50	0	67	474	1000	2	2
264	100	0	11	0	0	0	112	0	0	0	0	10	0	25	0	0	50	0	692	1000	2	2
265	100	0	39	0	0	30	0	0	0	0	0	0	147	0	25	50	0	0	609	1000	2	2
266	0	100	12	114	0	0	0	0	10	0	0	0	0	0	25	50	0	33	655	1000	2	2
267	100	0	11	30	0	0	0	0	0	0	150	0	0	0	25	0	50	0	634	1000	2	2
268	0	100	91	0	0	72	0	0	82	0	0	0	0	0	0	0	50	33	572	1000	2	2
269	100	0	61	0	0	43	0	0	0	216	0	0	0	0	0	0	0	33	546	1000	2	2
270	100	0	140	0	56	0	0	0	0	0	0	278	0	0	0	0	50	0	376	1000	2	2

271	0	100	302	0	106	0	0	0	0	0	120	0	0	0	0	50	0	67	256	1000	2	2
272	100	0	5	43	0	0	0	0	0	216	0	0	0	0	25	0	50	33	527	1000	2	2
273	0	100	12	72	0	0	0	0	0	0	82	0	0	0	0	0	50	33	650	1000	2	2
274	100	0	40	0	0	0	135	0	0	152	0	0	148	0	0	25	0	0	67	614	1000	2	2
275	100	0	11	31	0	0	0	0	0	0	0	0	0	0	0	0	50	0	67	426	1000	2	2
276	100	0	14	0	0	0	57	0	0	0	0	0	0	286	0	25	0	0	0	585	1000	2	2
277	100	0	5	0	0	0	0	135	0	150	0	0	0	0	0	0	0	50	33	514	1000	2	2
278	100	0	18	0	0	0	43	0	0	216	0	0	0	0	0	25	0	50	33	573	1000	2	2
279	0	100	108	0	0	0	0	71	0	0	117	0	0	0	0	0	0	0	0	663	1000	2	2
280	100	0	11	0	0	0	0	167	0	0	0	80	0	0	0	25	50	0	67	608	1000	2	2
281	0	100	19	0	0	0	0	0	0	0	0	0	14	0	0	25	0	50	33	405	1000	2	2
282	100	0	65	0	0	57	0	0	0	0	290	0	0	10	0	0	50	0	33	405	1000	2	2
283	0	100	353	0	116	0	0	0	0	0	0	15	0	0	0	25	50	0	67	279	1000	2	2
284	0	100	170	0	0	165	0	0	0	0	0	0	0	0	0	0	50	0	33	466	1000	2	2
285	0	100	12	167	0	0	0	0	0	0	0	0	0	15	0	0	0	0	67	639	1000	2	2
286	100	0	18	0	0	0	0	114	0	0	10	0	0	0	0	0	0	0	33	724	1000	2	2
287	0	100	12	136	0	0	0	0	0	0	154	0	0	0	25	0	50	33	488	1000	2	2
288	0	100	19	0	0	0	71	0	0	78	0	0	0	25	0	0	50	0	657	1000	2	2
289	0	100	6	0	0	0	116	0	0	0	0	0	10	0	25	0	50	67	626	1000	2	2
290	100	0	9	0	0	0	0	214	19	0	0	0	0	0	0	0	0	0	658	1000	2	2
291	0	100	6	103	0	0	0	0	0	0	0	0	0	114	0	50	0	0	602	1000	2	2
292	100	0	5	0	0	0	57	0	0	286	0	0	0	0	25	50	0	67	410	1000	2	2
293	100	0	44	0	0	0	0	163	0	0	15	0	0	0	0	0	50	0	628	1000	2	2
294	0	100	89	0	30	0	0	0	0	0	150	0	0	25	0	0	0	0	606	1000	2	2
295	0	100	233	0	0	214	0	0	19	0	0	0	0	25	0	0	50	0	359	1000	2	2
296	0	100	147	0	43	0	0	0	0	214	0	0	0	0	0	50	0	0	447	1000	2	2
297	100	0	18	135	0	0	0	0	0	0	0	0	150	25	0	50	0	0	522	1000	2	2
298	100	0	18	104	0	0	0	0	0	0	118	0	0	25	0	0	50	33	551	1000	2	2
299	0	100	645	0	216	0	0	0	0	0	19	0	0	0	25	0	0	33	39	1000	2	2
300	100	0	5	72	0	0	0	0	0	80	0	0	0	0	0	0	0	33	710	1000	2	2
301	0	62	4	0	0	0	32	0	0	0	0	0	158	15	0	0	31	41	658	1000	3	1
302	62	0	3	39	0	0	0	0	0	0	0	194	0	0	15	0	31	0	656	1000	3	1
303	0	62	8	40	0	0	0	0	0	197	0	0	0	0	0	0	0	21	673	1000	3	1
304	62	0	3	32	0	0	0	0	162	0	0	0	0	0	0	0	31	41	670	1000	3	1
305	0	62	117	0	0	114	0	0	0	0	0	125	0	0	15	0	0	0	566	1000	3	1
306	62	0	5	0	0	0	0	114	0	126	0	0	0	0	0	0	31	0	662	1000	3	1
307	0	62	127	0	0	0	0	181	16	0	0	0	0	0	0	0	0	0	614	1000	3	1
308	0	62	141	0	0	0	0	151	0	0	0	0	0	13	0	0	0	21	582	1000	3	1
309	0	62	8	119	0	0	0	0	0	10	0	0	0	0	0	15	31	0	21	734	1000	3	1
310	62	0	30	0	0	0	31	0	0	0	160	0	0	0	0	15	31	0	21	651	1000	3	1
311	0	62	12	0	0	0	0	48	0	242	0	0	0	0	0	15	0	31	0	591	1000	3	1
312	62	0	44	0	0	0	40	0	0	0	0	0	196	0	0	15	31	0	21	592	1000	3	1
313	62	0	4	0	0	0	0	39	0	0	200	0	0	0	0	0	0	0	0	695	1000	3	1
314	62	0	5	0	0	0	0	75	0	0	0	82	0	0	0	0	0	0	0	777	1000	3	1
315	0	62	12	149	0	0	0	0	0	0	0	0	13	0	0	31	0	0	0	734	1000	3	1
316	62	0	66	0	0	75	0	0	0	0	84	0	0	15	0	31	0	0	0	667	1000	3	1
317	0	62	46	0	0	0	0	39	0	0	0	194	0	0	0	0	0	0	0	659	1000	3	1

318	62	0	206	0	76	0	0	0	0	0	86	0	0	0	15	0	31	0	41	483	1000	3	1								
319	0	62	8	0	0	0	121	0	11	0	0	0	0	0	15	0	0	31	41	712	1000	3	1								
320	62	0	11	118	0	0	0	0	0	0	11	0	0	0	15	0	31	0	0	753	1000	3	1								
321	62	0	98	0	40	0	0	0	0	199	0	0	0	0	15	0	0	0	41	545	1000	3	1								
322	62	0	30	0	0	0	0	119	0	0	0	0	0	10	0	0	0	31	0	21	727	1000	3	1							
323	0	62	110	0	0	0	0	114	0	0	129	0	0	0	0	0	0	0	31	0	554	1000	3	1							
324	0	62	12	31	0	0	0	0	0	0	0	0	155	15	0	0	31	0	0	0	695	1000	3	1							
325	62	0	7	0	0	0	114	0	0	0	129	0	0	15	0	0	0	0	0	0	673	1000	3	1							
326	0	62	43	0	0	31	0	0	0	0	0	155	0	0	0	15	31	0	21	642	1000	3	1								
327	62	0	11	48	0	0	0	0	244	0	0	0	0	0	0	0	0	31	21	585	1000	3	1								
328	0	62	4	0	0	0	181	0	16	0	0	0	0	0	0	0	31	0	0	707	1000	3	1								
329	0	62	28	0	0	0	0	31	0	155	0	0	0	0	0	0	31	0	0	694	1000	3	1								
330	0	62	106	0	32	0	0	0	0	158	0	0	0	10	0	15	0	31	41	555	1000	3	1								
331	62	0	3	119	0	0	0	0	0	0	0	0	0	0	0	15	0	31	21	739	1000	3	1								
332	62	0	301	0	152	0	0	0	14	0	0	0	0	0	0	15	0	31	41	385	1000	3	1								
333	0	62	12	31	0	0	0	0	0	0	160	0	0	0	0	0	0	0	21	715	1000	3	1								
334	62	0	5	0	0	0	0	118	0	0	0	0	0	10	0	0	31	0	0	774	1000	3	1								
335	0	62	87	0	0	75	0	0	85	0	0	0	127	0	0	15	0	31	21	639	1000	3	1								
336	62	0	116	0	0	116	0	0	0	0	0	0	0	0	0	15	0	31	41	492	1000	3	1								
337	62	0	30	0	0	0	0	119	0	0	0	0	10	0	0	0	0	31	21	727	1000	3	1								
338	0	62	74	0	0	0	0	183	0	0	16	0	0	0	0	0	0	31	41	593	1000	3	1								
339	62	0	11	182	0	0	0	0	0	0	0	0	16	0	15	15	31	0	21	663	1000	3	1								
340	0	62	39	0	0	32	0	0	0	0	0	0	158	0	15	15	0	31	41	622	1000	3	1								
341	62	0	14	0	0	0	0	116	0	0	0	0	0	0	0	0	0	0	41	641	1000	3	1								
342	0	62	189	0	0	162	0	0	0	0	0	0	16	0	0	0	0	0	21	531	1000	3	1								
343	0	62	8	48	0	0	0	0	0	240	0	0	0	0	15	0	0	0	41	586	1000	3	1								
344	62	0	9	0	0	0	0	40	0	199	0	0	0	0	0	0	0	31	41	618	1000	3	1								
345	62	0	3	116	0	0	0	0	0	0	0	0	128	0	15	0	0	31	41	604	1000	3	1								
346	62	0	68	0	0	76	0	0	0	0	0	84	0	0	15	0	0	31	41	624	1000	3	1								
347	0	62	4	0	0	0	31	0	0	156	0	0	0	0	15	15	31	0	21	680	1000	3	1								
348	0	62	22	0	0	0	0	48	0	0	0	237	0	0	0	0	31	0	21	581	1000	3	1								
349	62	0	7	96	0	0	0	0	0	0	0	0	106	0	0	0	0	31	41	656	1000	3	1								
350	0	62	168	0	0	0	0	182	16	0	0	0	0	0	0	0	0	31	21	521	1000	3	1								
351	0	73	9	0	0	0	70	0	79	0	0	0	0	0	0	0	0	0	0	769	1000	3	1								
352	73	0	129	0	0	148	0	0	0	0	0	13	0	0	0	0	36	0	0	602	1000	3	1								
353	73	0	184	0	0	186	0	0	0	0	0	0	16	0	18	0	36	0	24	462	1000	3	1								
354	73	0	296	0	149	0	0	0	0	0	0	13	0	0	18	0	0	36	24	391	1000	3	1								
355	0	73	222	0	70	0	0	0	0	0	79	0	0	0	0	0	0	0	0	557	1000	3	1								
356	0	73	109	0	0	95	0	0	0	105	0	0	0	0	18	0	0	0	48	551	1000	3	1								
357	0	73	14	71	0	0	0	0	0	0	80	0	0	0	0	18	36	0	24	684	1000	3	1								
358	73	0	86	0	39	0	0	0	0	0	0	193	0	18	0	18	0	0	0	591	1000	3	1								
359	73	0	13	0	0	0	29	0	0	0	0	144	0	18	0	0	0	36	0	687	1000	3	1								
360	0	73	158	0	0	149	0	0	0	0	13	0	0	18	0	0	0	0	24	564	1000	3	1								
361	73	0	172	0	72	0	0	0	0	0	0	79	0	18	0	0	36	0	48	502	1000	3	1								
362	73	0	205	0	95	0	0	0	0	0	0	0	105	18	0	0	0	0	48	456	1000	3	1								
363	73	0	4	0	0	0	49	0	0	0	0	0	242	0	18	0	0	0	0	615	1000	3	1								
364	0	73	71	0	0	0	0	94	0	104	0	0	0	0	0	0	0	36	24	597	1000	3	1								

365	73	0	4	151	0	0	0	0	0	13	0	0	0	18	0	0	0	0	48	693	1000	3	1								
366	0	73	86	0	0	72	0	0	0	0	0	79	0	0	0	36	0	0	48	606	1000	3	1								
367	0	73	318	0	112	0	0	0	0	10	0	0	0	0	0	0	0	0	24	463	1000	3	1								
368	0	73	446	0	149	0	0	0	0	13	0	0	0	0	18	0	0	0	24	277	1000	3	1								
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370	0	73	4	0	0	0	0	185	0	0	0	16	0	0	18	0	0	0	0	704	1000	3	1								
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372	0	73	34	0	0	30	0	0	0	0	0	0	149	0	0	0	36	0	48	630	1000	3	1								
373	73	0	160	0	0	185	0	0	0	16	0	0	0	0	18	0	0	0	0	548	1000	3	1								
374	0	73	189	0	0	166	0	49	0	249	0	0	0	0	0	36	0	0	24	511	1000	3	1								
375	73	0	13	0	0	0	0	95	0	0	0	0	105	0	0	0	0	0	48	674	1000	3	1								
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377	0	73	333	0	118	0	0	0	0	0	133	0	0	0	0	0	0	36	48	652	1000	3	1								
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379	73	0	4	0	0	0	0	72	0	0	0	0	10	0	0	0	0	0	48	594	1000	3	1								
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393	0	73	53	0	0	39	0	0	0	0	0	0	198	0	0	0	0	0	0	0	638	1000	3	1							
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399	0	73	14	114	0	0	0	0	0	10	0	0	0	0	0	0	0	36	48	705	1000	3	1								
400	73	0	4	0	0	0	0	0	29	0	0	0	148	0	0	0	0	36	0	709	1000	3	1								
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403	0	100	421	0	135	0	0	0	0	153	0	0	0	0	0	25	0	0	0	166	1000	2	2								
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410	0	100	384	0	135	0	0	0	0	0	0	150	0	0	0	0	25	0	0	0	206	1000	2	2							
411	0	100	122	0	0	116	0	0	0	0	0	0	0	0	10	0	25	0	0	67	560	1000	2	2							

412	100	0	5	44	0	0	0	0	224	0	0	0	0	0	25	0	50	0	67	485	1000	2	2								
413	0	100	179	0	0	167	0	0	0	0	15	0	0	0	25	0	0	50	67	397	1000	2	2								
414	100	0	120	0	0	104	0	0	0	0	0	0	113	0	0	0	0	0	33	526	1000	2	2								
415	0	100	56	0	0	44	0	0	224	0	0	0	0	0	0	25	0	50	67	434	1000	2	2								
416	100	0	140	0	56	0	0	214	0	0	287	0	0	0	25	0	0	0	0	392	1000	2	2								
417	100	0	5	0	0	0	214	103	0	0	0	0	0	114	0	25	50	0	0	637	1000	2	2								
418	100	0	5	0	0	0	103	135	0	0	0	153	0	0	0	0	50	0	0	628	1000	2	2								
419	100	0	11	0	0	0	135	0	114	0	10	0	0	0	0	25	50	0	0	526	1000	2	2								
420	0	100	88	0	0	0	0	114	0	83	0	0	0	0	0	0	0	0	33	654	1000	2	2								
421	0	100	12	73	0	0	0	0	0	0	0	0	0	0	0	25	0	50	67	589	1000	2	2								
422	100	0	67	0	30	0	0	0	0	0	0	0	146	0	0	0	0	50	0	607	1000	2	2								
423	100	0	78	0	0	71	0	0	0	0	0	0	78	0	0	25	50	0	0	598	1000	2	2								
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425	0	100	208	0	72	0	0	0	0	80	0	0	0	0	0	0	0	0	33	506	1000	2	2								
426	100	0	9	0	0	0	0	214	0	19	0	0	0	0	0	0	0	0	0	658	1000	2	2								
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434	100	0	11	135	0	0	0	0	0	0	0	0	148	0	25	0	50	0	0	530	1000	2	2								
435	100	0	272	0	114	0	0	0	0	0	10	0	0	0	0	25	0	0	33	445	1000	2	2								
436	100	0	5	0	0	0	43	0	218	0	0	0	0	0	25	0	0	50	0	559	1000	2	2								
437	0	100	126	0	43	0	0	0	0	0	219	0	0	0	0	0	50	0	0	462	1000	2	2								
438	100	0	54	0	0	57	0	0	0	286	0	0	0	0	0	0	0	0	67	436	1000	2	2								
439	0	100	490	0	163	0	0	0	0	14	0	0	0	0	0	25	0	0	0	208	1000	2	2								
440	100	0	18	0	0	0	214	0	0	0	19	0	0	0	0	0	0	50	0	599	1000	2	2								
441	100	0	5	30	0	0	0	0	0	147	0	0	0	0	25	0	50	0	0	643	1000	2	2								
442	100	0	18	103	0	0	0	0	116	0	0	0	0	0	0	25	0	50	0	588	1000	2	2								
443	0	100	6	0	0	0	72	0	0	0	0	0	0	80	0	0	50	0	33	659	1000	2	2								
444	0	100	19	103	0	0	0	0	0	0	117	0	0	0	0	0	50	0	0	611	1000	2	2								
445	100	0	180	0	0	165	0	0	0	0	0	0	0	14	0	0	0	0	33	507	1000	2	2								
446	100	0	11	116	0	0	0	0	10	0	0	0	0	0	25	0	0	0	67	671	1000	2	2								
447	100	0	435	0	163	0	0	0	0	0	0	0	0	14	0	0	0	50	0	238	1000	2	2								
448	0	100	12	214	0	0	0	0	0	0	19	0	0	0	0	25	0	50	0	579	1000	2	2								
449	0	100	294	0	103	0	0	0	0	0	0	114	0	0	0	25	0	0	0	364	1000	2	2								
450	0	100	6	138	0	0	0	0	0	0	0	0	151	0	0	0	0	50	67	488	1000	2	2								

We claim:

1. A method for forming dyed protein crystals comprising:
   (a) providing a protein solution, wherein the protein solution contains at least one dye, which dye is capable of dyeing at least a portion of protein crystals formed from the protein solution;
   (b) subjecting the protein solution to environmental conditions effective to form protein crystals; and
   (c) detecting the presence of dyed protein crystals, whereby the presence of the dyed protein crystals indicates the presence of protein crystals.

2. The method of claim 1, wherein the dye is selected from the group consisting of methylene blue, methylene green, Izit and crystal violet.

3. The method of claim 1, wherein the dye binds to protein molecules of the protein crystals formed from the protein solution.

4. The method of claim 1, wherein the dye does not bind to protein molecules of the protein crystals formed from the protein solution and wherein molecules of the dye reside in channels present in the protein crystals.

5. The method of claim 1, wherein the protein solution is partitioned from the atmosphere.

6. The method of claim 5, wherein the protein solution is overlayed with an oil selected from the group consisting of paraffin oil, silicone oil and combinations thereof.

7. The method of claim 1, wherein the protein solution further comprises a component selected from the group consisting of salts, buffers, precipitants, crystallization aids and any combination thereof.

8. The method of claim 7, wherein the component crystallizes under the environmental conditions of (b).

9. The method of claim 8, wherein step (b) comprises addition of a precipitate solution.

10. The method of claim 8, wherein the component crystals are undyed component crystals.

11. The method of claim 8, further comprising detecting crystals formed in the provided protein solution and distinguishing dyed protein crystals from undyed component crystals.

12. The method of claim 11, wherein the protein crystals and the component crystals are detected by microscopy.

13. A method for screening protein crystal growth conditions, comprising:
(a) providing a set of at least two protein solutions, wherein the protein solutions contain a dye, which dye (i) is capable of dyeing at least a portion of protein crystals formed from the protein solution and (ii) does not dye a significant portion of component crystals formed from the protein solution;
(b) subjecting the protein solutions to predetermined conditions, wherein the environmental conditions to which each member of the set of protein solutions is subjected is not identical to the environmental conditions to which another member of the set is subjected; and
(c) detecting the presence or non-presence of dyed protein crystals and/or undyed component crystals, wherein;
(i) the presence of the dyed protein crystals indicates the formation of protein crystals; and

(ii) the presence of undyed component crystals indicates formation of component crystals.

14. The method of 13, wherein the set of protein solutions consists of greater than 10 protein solutions.

15. The method of 14, wherein the set of protein solutions consists of greater than 100 protein solutions.

16. The method of claim 13, wherein the dye is selected from the group consisting of methylene blue, methylene green, Izit and crystal violet.

17. The method of claim 13, wherein the protein solutions are partitioned from the atmosphere.

18. The method of claim 17, wherein the protein solutions are overlayed with an oil selected from the group consisting of paraffin oil, silicone oil and combinations thereof.

19. The method of claim 13, wherein the protein solution further comprises a component selected from the group consisting of salt, buffer, precipitant, crystallization aid and any combination thereof.

20. The method of claim 13, wherein the component crystallizes under the environmental conditions of (b).

21. The method of claim 20, wherein step (b) comprises addition of a precipitate solution.

22. The method of claim 20, wherein the component crystals comprise undyed component crystals.

23. The method of claim 22, further comprising distinguishing dyed protein crystals from undyed component crystals.

24. The method of claim 23, wherein dyed protein crystals are distinguished from component crystals by use of microscopy.

25. The method of claim 13, wherein detection of dyed protein crystals indicates a combination of conditions to promote crystal growth of a protein in the provided protein solution.

26. The method of claim 25, wherein the detected dyed protein crystals are evaluated in respect to protein crystal quality.

27. The method of claim 26, wherein the evaluation of protein crystal quality includes criterion selected from the group consisting of size of crystals, volume of crystals, intensity of coloration of crystals by dye, color of coloration of crystals by dye, sharpness of crystal edges, crystal shape and combinations thereof.

28. A method for forming dyed component crystals comprising
    (a) providing a component solution, wherein the component solution contains at least one dye, which dye is capable of dyeing at least a portion of component crystals formed from the component solution;
    (b) subjecting the component solution to environmental conditions effective to form component crystals; and
    (c) detecting the presence of dyed component crystals, whereby the presence of the dyed component crystals indicates the presence of component crystals.

29. The method of claim 28, wherein the component solution is partitioned from the atmosphere.

30. The method of claim 29, wherein the component solution is overlayed with an oil selected from the group consisting of paraffin oil, silicone oil and combinations thereof.

31. The method of claim 28, wherein the component solution further comprises a protein.

32. The method of claim 29, wherein the protein crystallizes under the environmental conditions of (b).

33. The method of claim 32, wherein step (b) comprises addition of a precipitate solution.

34. The method of claim 32, wherein the protein crystals comprises undyed protein crystals.

35. The method of claim 32, further comprising detecting any crystals formed in the provided component solution and distinguishing the undyed protein crystals from the dyed component crystals on the basis that the component crystals are dyed component crystals and the protein crystals are undyed protein crystals.

36. The method of claim 35, wherein the protein crystals and the component crystals are detected by microscopy.

37. A method for screening protein crystal growth conditions, comprising:

(a) providing a set of at least two protein solutions, wherein the protein solutions contain a dye, which dye (i) is capable of dyeing at least a portion of component crystal formed from the protein solution and (ii) does not dye a significant portion of protein crystals formed from the protein solution;

(b) subjecting the protein solutions to predetermined conditions, wherein the environmental conditions to which each member of the set of protein solutions is subjected is not identical to the environmental conditions to which another member of the set is subjected; and

(c) detecting the presence or non-presence of undyed protein crystals and/or dyed component crystals, wherein;

(i) the presence of undyed protein crystals indicates the formation of protein crystals; and

(ii) the presence of dyed component crystals indicates formation of component crystals.

38. The method of 37, wherein the set of protein solutions consists of greater than 10 protein solutions.

39. The method of 38, wherein the set of protein solutions consists of greater than 100 protein solutions.

40. The method of claim 37, wherein the protein solution is partitioned from the atmosphere.

41. The method of claim 40, wherein the protein solution is overlayed with an oil selected from the group consisting of paraffin oil, silicone oil and combinations thereof.

42. The method of claim 37, wherein the protein solution further comprises a component selected from the group consisting of salt, buffer, precipitant, crystallization aid and any combination thereof.

43. The method of claim 37, wherein the protein crystallizes under the environmental conditions of (b).

44. The method of claim 43, wherein step (b) comprises addition of a precipitate solution.

45. The method of claim 43, wherein the protein crystals comprise undyed protein crystals.

46. The method of claim 45, further comprising distinguishing the undyed protein crystals from the dyed component crystals.

47. The method of claim 46, wherein the undyed protein crystal is distinguished from the component crystals by use of microscopy.

48. The method of claim 37, wherein detection of the undyed protein crystals indicates a combination of conditions to promote crystal growth of a protein in the provided protein solutions.

49. The method of claim 48, wherein the detected undyed protein crystals are evaluated in respect to protein crystal quality.

50. The method of claim 49, wherein the evaluation of protein crystal quality includes criterion selected from the group consisting of size of crystals, volume of crystals,

intensity of coloration of crystals by dye, color of coloration of crystals by dye, sharpness of crystal edges, crystal shape or combinations thereof

51. An automated method of screening protein crystal growth conditions comprising the steps of:
    a) providing a set of at least two protein solutions, wherein the protein solutions contain a dye, which dye (i) is capable of dyeing at least a portion of protein crystals formed from the protein solution and (ii) does not dye a significant portion of component crystals formed from the protein solution;
    b) dispensing the protein solutions onto a platform, wherein the protein solutions are dispensed using an automated dispensing system in accordance with a predetermined program;
    c) controlling the protein crystal growth conditions of the protein solutions; and
    d) detecting the presence or non-presence of dyed protein crystals and/or undyed component crystals, wherein the presence of the dyed protein crystals indicates the formation of protein crystals; and the presence of undyed component crystals indicates the formation of component crystals.

52. The method according to claim 51 wherein protein solutions on the platform are overlayed with an oil.

53. A method for screening protein crystal growth conditions, comprising:
    a) providing a set of at least two protein solutions, wherein the protein solutions contain a dye, which dye (i) is capable of dyeing at least a portion of component crystals formed from the protein solution and (ii) does not dye a significant portion of protein crystals formed from the protein solution;

b) dispensing the protein solutions onto a platform, wherein the protein solutions are dispensed using an automated dispensing system in accordance with a predetermined program;

c) controlling the protein crystal growth conditions of the protein solutions; and

d) detecting the presence or non-presence of undyed protein crystals and/or dyed component crystals, wherein the presence of the undyed protein crystals indicates the formation of protein crystals; and the presence of the dyed component crystals indicates formation of component crystals.

54. The method according to claim 53 wherein the protein solutions on the platform are overlayed with an oil.

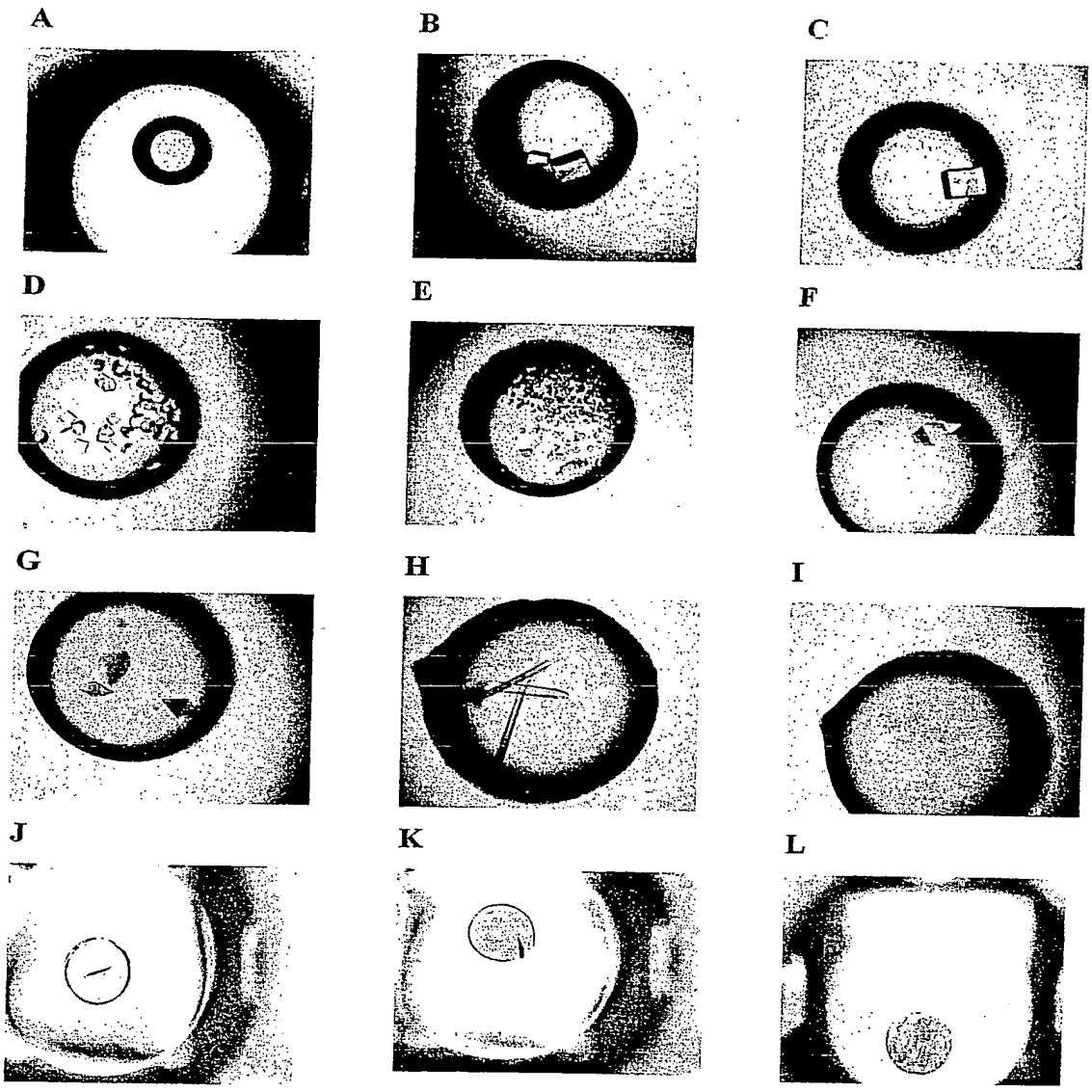

Figure One

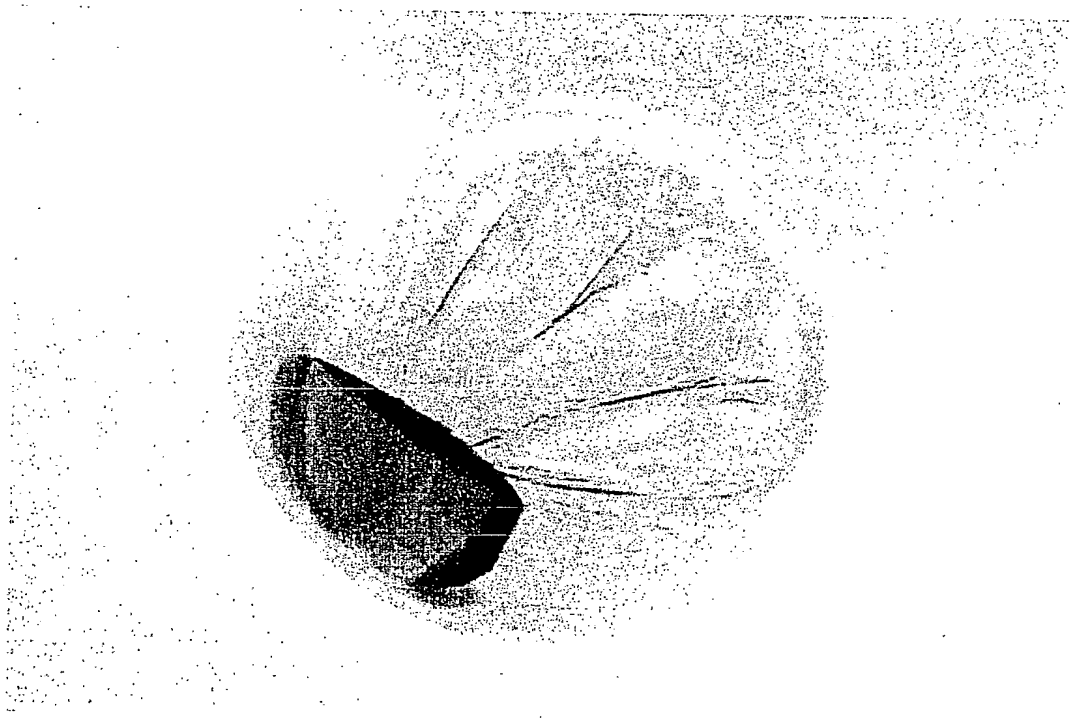

Fig. 2

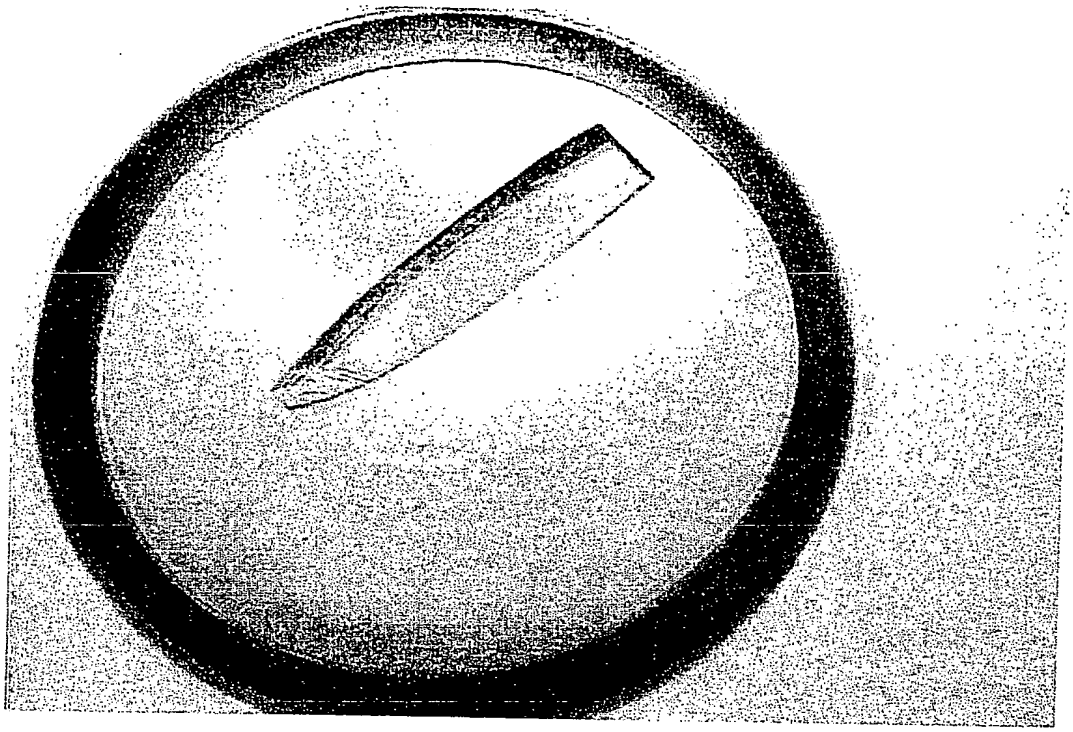

Fig. 3

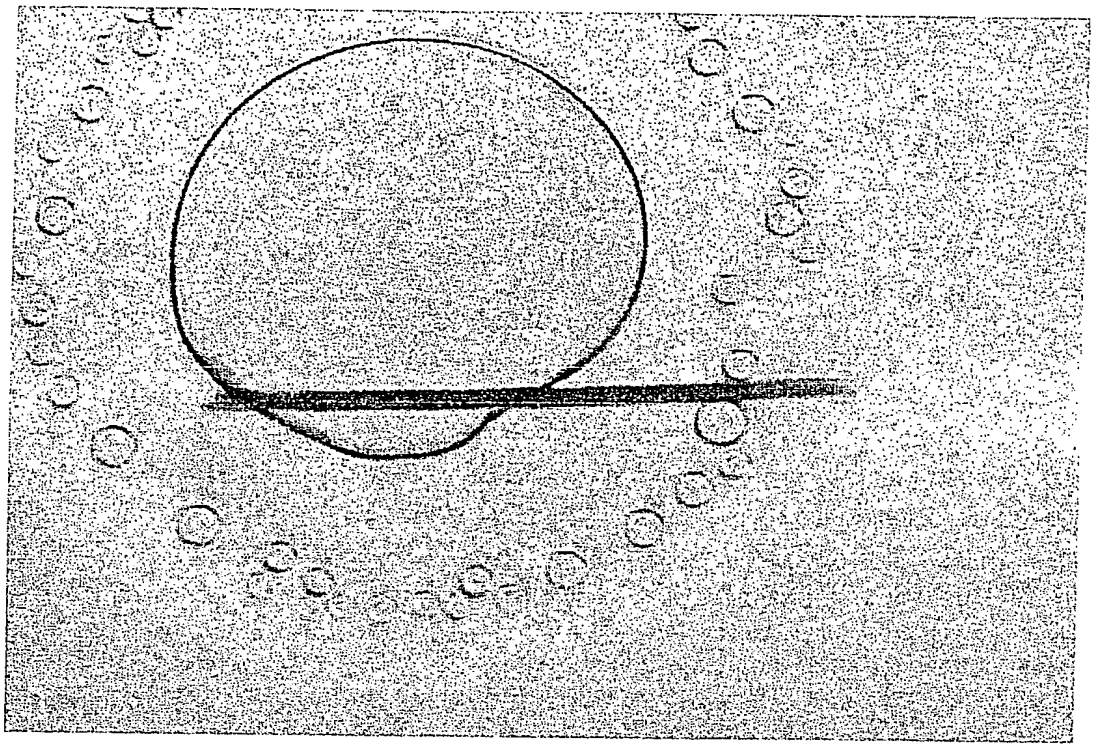

Fig. 4

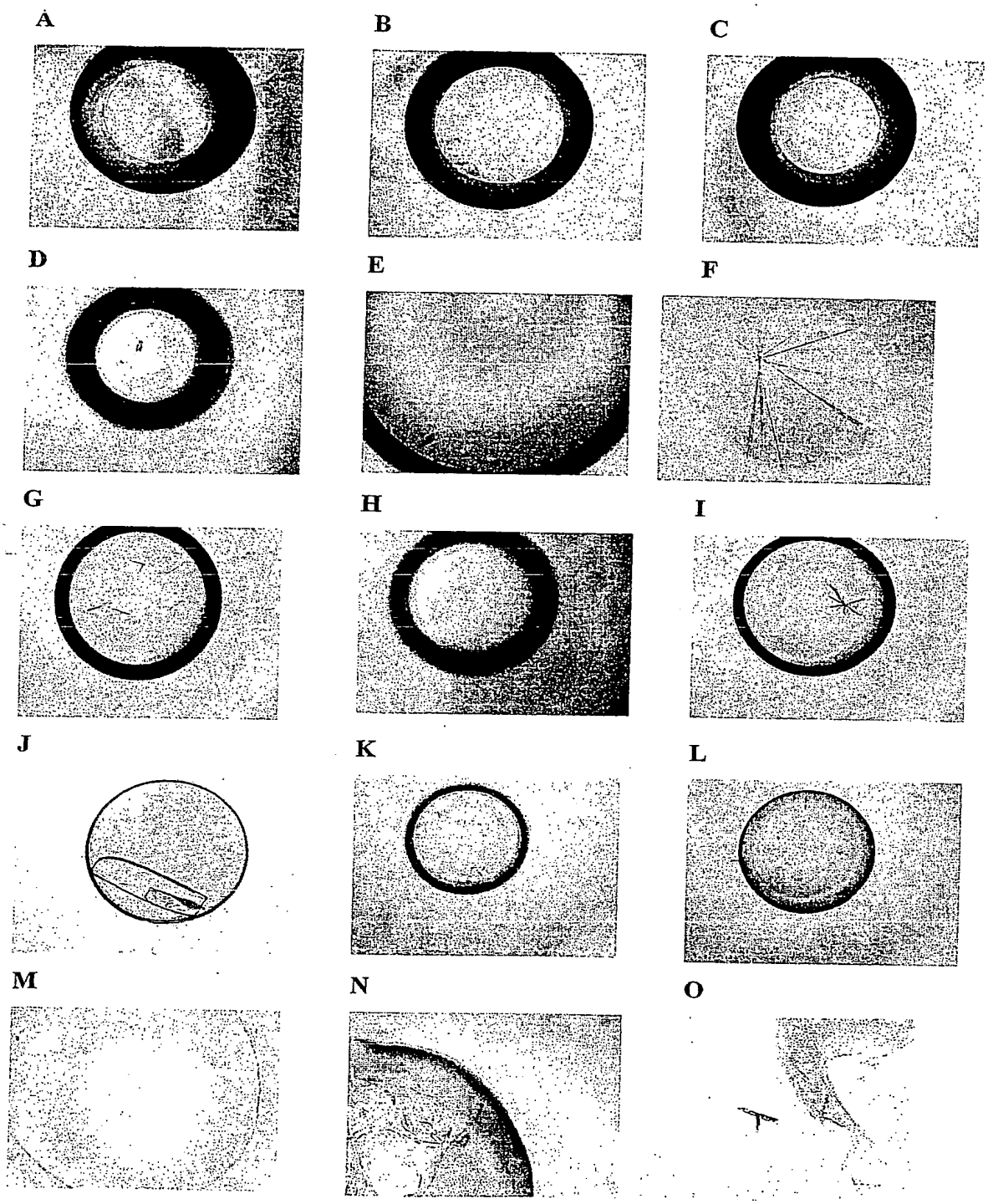

Figure Five

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US02/24032

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) : G01N 31/00
US CL : 436/86, 164
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 436/86, 164

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,013531 A (SNYDER et al) 7 May 1991 (07.05.1991), abstract.	1-54
A	US 4,517,048 A (SHLICHTA) 14 May 1985 (14.05.1985), abstract.	1-54
A,E	US 6,468,346 B (ARNOWITZ et al). 22 October 2002 (22.10.2002), abstract.	1-54
A,P	US 6,406,903 B (BRAY et al) 18 June 2002 (18.06.2002), abstract.	1-54

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
03 November 2002 (03.11.2002)

Date of mailing of the international search report
03 DEC 2002

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Form PCT/ISA/210 (second sheet) (July 1998)